AN ECONOMIC ANALYSIS OF THE IMPACT OF GENDER AND OTHER FACTORS ON SMALLHOLDER DAIRY PRODUCTIVITY: THE CASE OF EMBU DISTRICT, KENYA

BY

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A Thesis Submitted in Partial Fulfillment for the Degree of Masters of Science in Agricultural Economics, University of Nairobi

DECLARATION

This thesis is my original work and has not been submitted for a degree in any other university.

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This thesis has been submitted for examination with our approval as University Supervisors.

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LIST OF ACRONYMS

FAO	Food and Agriculture Organization
FAWE	Forum of African Women Educationists
ICRAF	International Center for Research in Agroforestry
IEA	Institute of Economic Affairs
ILCA	International Livestock Center for Africa
ILRI	International Livestock Research Institute
KARI	Kenya Agricultural Research Institute
KEFRI	Kenya Forestry Research Institute
KENGO	Kenya Energy and Environment Organizations
KEPAWAE	Kenya Professional Association of Women in Agriculture and Environment
KWAP	Kenya Woodfuel and Agroforestry Project
MoALDM	Ministry of Agriculture, Livestock Development and Marketing
NARP	National Agroforestry Research Project
NDDP	National Dairy Development Project
NGO	Non-Governmental Organizations
ROK	Republic of Kenya
UN	United Nations

ACKNOWLEDGEMENT

I gratefully acknowledge the power of God the Creator, for having made it possible for me to receive a scholarship and to go through my studies at the University of Nairobi.

Special thanks are due to my University supervisors, Dr. Kimenye and Prof. Mbogoh for patiently going through this work and giving it shape. However, I personally take full responsibility for all errors.

I will never give conclusive thanks to the staff in the Department of Agricultural Economics at the University of Nairobi. First and foremost, Prof. Oluoch-Kosura, the chairman of the department who was my academic icon and a personal encouragement. Other staff members, Dr. Karugia, Dr. Kilungo, Ms Ritho and Grace our secretary, besides many others. Your support was immeasurable. I won't forget Dr. Nyariki of the department of Range Management for his help in my literature search and his useful comments.

Rockefeller's FORUM project and the University of Nairobi provided the funds for research, data processing and preparation of this thesis. I acknowledge this support with gratitude.

I thank the farmers in Manyatta and Runyenjes Divisions of Embu District for their time and understanding in answering my questionnaires. My colleagues and friends, Wanyoike, Rose, Khisa and many others whom I can't mention by name. Thank you profusely for your help without which I would not have done this work.

Finally, I thank my wife Ann and my sons Innocent and Ivan for being to me, a beam of hope and encouragement. You all bore my absence from home with understanding. I also extend many thanks to my mother, Fridah and late father Mulindo. Thank you for seeing me thus far in academics. I hold you responsible for every success in my life.

DEDICATION

I dedicate this thesis to my sons Innocent and Ivan who are and will remain the reason for that extra input from my life.

ABSTRACT

The problem of diminishing dairy productivity and thus dairy production in the face of rising population density is not unique to Kenya, but is an issue of concern for sub-Saharan Africa. Lack of affordable good quality dairy feeds poses the greatest challenge to the efforts being made to raise dairy productivity. Improved fodder plants dairy technology offers the best option as a substitute or supplement to the expensive commercial dairy meals. In Kenya, efforts to develop and disseminate this technology to smallholder dairy farmers have been on for over a decade. Although efforts to raise dairy productivity are being done, it is not known how they impact on the farmers on the basis of their gender because men and women farmers are faced with different opportunities and constraints.

This study investigated the effect of improved fodder plants and zero grazing dairy technologies on the performance of male and female smallholder dairy farmers. The gender of the dairy farmers was considered in order to analyse if there is performance variation due to the different circumstances male and female farmers are exposed to in their farming activities. Three hundred and one smallholder dairy farmers were interviewed in Manyatta and Runyenjes divisions of Embu District by use of a semi-structured questionnaire. The households were grouped into male-headed and female-headed. Within each of the two household groups, there exist male-managed, female-managed or jointly managed dairy enterprises. Categorization at the two levels was based on the preposition that female dairy managers from male-headed households differ in resource endowment levels to those from female-headed households and so do the male dairy enterprise managers. Statistical analysis helped in determining the comparative objectives. The Cobb-Douglas production model was estimated with a view of determining the influence of the various socio-economic factors on dairy performance.

Nearly every dairy farm (98 per cent of the sample size) was practicing some form of zero grazing,

implying that many farmers had adopted the technology. Male farmers were realizing higher dairy performance (dairy productivity of 8.90 litres per animal per day) than female farmers (7.00 litres per animal per day), mainly because the latter, especially within female-headed households were on average poorer than their male counterparts. Also, adopters of the improved technologies (dairy productivity of 7.19 litres per animal per day) achieved higher dairy performance than the non-adopters (5.51 litres per animal per day). An assessment of male-managed and jointly managed dairy enterprises showed that the improved fodder plants adopters posted higher dairy performance than their non-adopter counterparts.

Availability of market for raw milk, access to commercial dairy feeds, control of the dairy benefits by the dairy enterprise manager, education level of the female dairy enterprise manager and monthly income were found to positively influence dairy performance.

The variation in dairy performance between male and female farmers implies that efforts to enhance dairy performance should consider the gender of the farmer with a view to ensure that all of them benefit from the efforts. The importance of improved fodder plants in dairy was shown and therefore efforts to ensure more of the farmers adopt the technology should be enhanced.

Encouraging the formation of dairy co-operatives to process and market milk for the farmers may provide an avenue to try and alleviate the problem of unavailability of market for raw milk. Efforts to develop and manufacture cheaper but safer and high quality dairy feeds should be instituted with a view to meet the demands of the low-income smallholder dairy input market.

CHAPTER ONE: INTRODUCTION

1.0. BACKGROUND TO THE STUDY

The statistics in support of the importance of livestock production world-wide are impressive. Nearly two billion people- a third of the world's population- derive at least some livelihood from farm animals; nearly one person in every eight depends almost entirely on livestock. Domestic animals perform many functions. For example, they provide for more than 30% of people's food needs. They also provide manure, draft power and hides, to mention a few (Wilson *et al*, 1995). Smallholder dairying demonstrates all these functions, notwithstanding the importance of the large-scale operation. Globally, the market value of milk production is second only to rice in the arid and semi-arid tropics of South and South-East Asia, second to beef in the sub-humid tropics and sub-tropics of South and Central America, and exceeds that of all other food commodities, including coffee, in the warm humid tropics of South and Central America (Wilson *et al*, 1995). In Africa as a whole, smallholder dairying generates more regular income than any other rural farm enterprise (ILCA, 1995).

Dairying in Kenya, like in all sub-Saharan Africa, is dominated by smallholder farmers, who are estimated to contribute about 55 per cent of total milk production (Peeler and Omore, 1997). Statistics indicate that 82 per cent of the total population of Kenya lives in the rural areas, and almost 70 per cent of these are found on smallholdings (Duncan and Howell, 1992). Smallholder farmers, besides growing crops for subsistence and sale, also mostly keep two to three cows with their followers. Their land sizes are typically of one hectare in the intensively farmed areas and about 2.5 hectares in the extensively farmed areas (Staal *et al*, 1998; MoALDM/KARI/ILRI, 1999). In Kenya, there is an estimated total population of

2.5 million dairy cattle in about 625,000 smallholdings (MoALDM, 1996; Peeler and Omore, 1997). These figures suggest that the subsector employs many Kenyans who must derive from it a regular source of income and nutrition (Omore *et al*, 1997).

Smallholder dairy farming produces most milk in Kenya, though individual cow productivity on average is lower than expected (Omore *et al*, 1996; Staal *et al*, 1998). Potential annual milk yield of a dairy cow (crosses and grades) on average, under existing Kenyan conditions, is 6,000 litres but only 1,300 litres is actually realized (MoALDM, 1995). Nationally, the dairy sub-sector has the potential to produce 4 billion litres of milk annually, but it only manages to produce a dismal 2.2 billion litres, while the local demand is 2.1 litres annually (ROK, 1997; Institute of Economic Affairs, 1998). Therefore, about 1.8 billion litres of milk is untapped. Besides deficient national policy provisions, drought and sporadic disease outbreaks, the greatest constraint to increased dairy productivity and hence dairy production is low quality and quantity of available livestock feeds. A survey done in 1991 in the districts of West Pokot, Trans Nzoia and Keiyo Marakwet to diagnose the major causes of low milk production identified the inadequate quantity and quality of available feeds as a major constraint (Ndikumana and de Leeuw, 1991).

Opportunities for increased dairy productivity nationally continue to be enhanced through agricultural technology development. Zero grazing, as one of these technologies, is as old as the introduction of the grade dairy cattle in the country. The zero grazing technology involves the cutting and carrying forage to dairy animals that are confined to a shelter. Their introduction was by the former colonial masters and their adoption has been continuous over time, mainly due to diminishing land size *vis-à-vis* increasing population. Efforts by the Kenya Agricultural Research Institute (KARI), universities and several international

research institutes/centres have come up with protein-rich leguminous fodder plants as cheaper substitutes for the expensive commercial feeds. Besides technology development, substantial efforts have been made to disseminate the technologies to the farmers, mainly by the Ministry of Agriculture, Livestock Development and Marketing (MoLDM) and some NGOs for instance the Catholic Church, the Kenya Energy and Environmental Organizations (KENGO) and Kenya Woodfuel and Agroforestry programme (KWAP).

Improved technologies can impact positively on dairy productivity and dairy production if the farmers for whom they were intended implement them. The farmers appear in many categories; male or female, large scale or small scale, sophisticated or peasants, among other categories. In sub-Saharan Africa, technology generation and transfer is geared towards a farmer who in most cases is assumed to be male. As Saito and Weidemann (1990) point out, this is sometimes by design, but more often by default. It is assumed that the technology will "trickle across" to the women, which in reality does not happen. The men are usually taken as the household heads or managers of farm enterprises and the women are subordinates. The scenario on the ground gives a different view. Many women are now heading households and managing various farm enterprises. Their involvement in agriculture is significant not only in terms of their labour input, but also in terms of their decision-making authority (Saito and Weldemann, 1990; and Adepoju *et al*, 1994). For instance, it has been found out that in some districts of Luapula and Northern Provinces of Zambia, the proportion of women farm managers can be as high as 50 – 70 per cent. Similarly, in some districts of Eastern and Central Provinces of Kenya, up to 90 per cent of smallholder farms are managed by women. The combination of "push" and "pull" factors such as abject poverty in the rural areas and higher prospects of employment in urban areas have drawn

men from the rural areas to the urban centres.

Women in Kenya contribute seventy five per cent of the total agricultural labour force (World Bank, 1994; Kimenye, 1998). In smallholder dairying, women are fully involved in almost all aspects of its development. They perform 50 per cent of the dairy work compared to men's 26 per cent. Children and hired labour do the remaining work (Ministry of Livestock Development, 1990). Perhaps women manage 40 per cent of Kenya's smallholdings, and it may be true that they probably exert substantial influence over the remainder (World Bank, 1989). However, unlike men, women face a number of structural constraints such as poor access to agricultural information and credit, which negatively affect their contribution in terms of farm productivity. In addition, alternative demands on their time from domestic duties further complicates their position by limiting their time for agricultural production (Roberts, 1996; and World Bank, 1989). These structural disadvantages hinder women from realizing their potential in agricultural production, and yet they form a significant proportion of the smallholder dairy farmers in the country. So far efforts to try and raise productivity in dairy have failed to account for this scenario. It is no wonder that the gap between real and potential dairy productivity has remained wide. Clearly, any efforts towards improving agricultural production in general and dairy in particular should take these facts into account. This work was conceptualized as a gender differentiated dairy production and dairy productivity study in Embu District. In particular it examined the effect of improved dairy technologies on dairy production and productivity of farmers (women and men farmers) and the implications the technologies have on gender relationships. Women and men farmers face different constraints and incentives in the face of new technologies and therefore respond differently and are impacted differently by them.

The conceptualization of this study as gender differentiated took these in consideration in an effort to avoid making blanket recommendations that favour one gender category of farmers to the disadvantage of the other.

1.1. PROBLEM STATEMENT

Dairying is an important economic enterprise in Embu district, just as it is in other parts of the Central and Eastern Highlands. Here, more than 80 per cent of farmers are involved in smallholder dairy farming. The farmers use most of the milk produced to feed their families and sell the rest to earn cash to meet other needs. Unfortunately, acute shortages in livestock feed force many farmers to spend a significant proportion of the income (if they have access to it) on commercial dairy meal supplements. This has had negative welfare impacts on the farmers and their households, for they are left with little savings to invest or to meet household food security. The overall situation is low milk yield per cow per unit time, which implies low total milk output nationally. Given the high rate of population growth and urbanization in the country, there is need to work out ways of increasing the rate of dairy production and dairy productivity to satisfy the increasing demand.

In order to address the feed problem, KARI in collaboration with the Kenya Forestry Research Institute (KEFRI) and the International Centre for Research in Agroforestry (ICRAF) identified and disseminated a number of fodder plants in Embu district. Chief among these was *Calliandra calothyrsus*. Others were *Leucaena leucocephala*, *Medicago sativa* and *Sesbania sesban*. These have been disseminated to the smallholder farmers in the region over the past decade or so (Kimenye, 1998). However, there has been no comprehensive investigation to ascertain the effect of this effort on the dairy production and

dairy productivity of smallholder farmers in the district. The studies done so far by both Franzel *et al* (1996) and Kimenye (1998) focused on early stages of adoption and an assessment of the dissemination strategies to popularize the technology respectively. One thing coming out of the latter study is that the gender of the farmer plays an important role in access to extension services, which is the pathway through which the improved fodder plant technologies (and other technologies) reach farmers.

Farmers operate within the confines of a household. A household is defined by its members who mainly live together and eat from the same "pot". Every household has a head whose authority is accepted by all the other members. This may be the single most important reason why households are taken as the units of analysis in most economic studies. In the past, African culture could only accommodate male household heads and this belief has been carried forward and is still persistent even with present day scholars. Therefore, economic studies in rural agriculture assume homogeneous households whose head or "farmer" is male (Udry, *et al*, 1995). This has been a chronic source of inefficient policies in rural farming over time. The important role played by women as household heads has become distinct with transformation in cultures over time. Widowhood and single parenthood no longer carry the same stigma they used to, previously. As already indicated, the dominance of female-managed smallholder farms has been encouraged by both 'pull' and 'push' factors that have made men to disengage from smallholder rural agriculture and women to take over the management roles (Adepoju *et al*, 1994). These, besides many other factors, have encouraged men to migrate from the rural areas to cities leaving women in capacities of *de facto* or *de jure* farm managers (Saito and Weidemann, 1990). The rural agricultural setup is such that there are both male and female-headed households at one

level. At another lower level, the agricultural enterprises within the households are male-managed, female-managed or jointly managed. So far, there has been no comprehensive study incorporating this rural agriculture setup despite its elegance and ability to capture the real situation existing in smallholder rural agriculture.

Given that women are now important in smallholder agriculture, an understanding of their farming and resource management roles, incentives and constraints is a pre-requisite to devising strategies aimed at raising their performance in dairy in particular and agriculture in general. This would translate into an improved overall dairy performance nationally. In addition, women are known to take a more dominant position in ensuring well-fed families (Inoti, *et al*, 1994). Thus an increase in dairy performance by women will boost national food security, reduce malnutrition among children and improve rural household welfare. Such an understanding can be gained through an evaluation structured as a gender differentiated dairy productivity analysis. The current study addresses the effect of the improved fodder plants technology and other technologies, on smallholder dairy production and dairy productivity by the various gender categories of farmers. Availability of such information will go a long way in providing material necessary for policy making with the aim of improving the performance of the dairy subsector.

1.2 JUSTIFICATION

Most agricultural development literature has not conclusively addressed the issue of social and economic factors that create gender disparities in access to and control of resources and output with its consequent implications to the performance of the industry. In Kenya, agricultural studies that incorporate gender analysis gained prominence not more than one

and half decades ago.

This study sought to find the effect of the adoption of *Calliandra Calothyrsus* as one technology, and other technologies (like zero grazing) on dairy production and productivity of smallholder farms in Embu District of Eastern Province of Kenya. It also tried to determine the differences in dairy production and productivity between households headed by male and female farmers and between dairy enterprises managed by male and female farmers and as well as to ascertain the significance of the socio-economic factors in shaping this pattern.

The study was justified by the following reasons:

(a) Women smallholder farmers are important and any attempt to improve production and productivity is not complete unless their productivity is also improved (Nindi, 1992). According to Boserup (1970), intensification is required to increase agricultural production and productivity, but intensification which goes with technology utilization generally, however, leads to a decrease in women's participation in agriculture, often displacing them from their major means of material production. An analysis that incorporates the subject of gender is a more objective way of capturing separately women's and men's contributions to agricultural performance as a prerequisite to devising ways to improve output.

(b) Improved fodder plants are as good as commercial feeds, but they are cheaper and more readily accessible to smallholder farmers. There is need to investigate the effect they have had on the performance of the dairy subsector since their introduction in the region.

(c) The human population in the country is about 30 million. This represents a population growth rate of 3.2 per cent in the last ten, which reflects a similar increase in demand for milk and milk products, *ceteris paribus*. Therefore, there is need to raise dairy production and productivity to cope with the rising demand for milk and dairy products *vis-à-vis* the diminishing land units.

This study further investigated the significance that some social and economic factors have in determining the levels of dairy production and productivity for both gender categories of farmers. The factors examined include accessible land sizes, labor, capital, market and institutional factors and household factors.

The study was expected to be of valuable use to policy makers and planners when considering ways of increasing dairy production and productivity and income of the smallholder farmers in an effort to improve their welfare.

1.3 OBJECTIVES OF THE STUDY

The overall objective of this study was to assess the performance of dairy enterprises operated by male and female smallholder dairy farmers in the light of the efforts being made for them to utilize improved fodder plants technology as a cheaper substitute to the more expensive commercial dairy feeds.

The specific objectives were to:

(a) Assess the dairy production and productivity differences among smallholder male and female smallholder dairy farmers.

(b) Assess the dairy production and productivity differences between farms where improved fodder plants technology (and other technologies like zero grazing) have been adopted and those farms where such technologies have not been adopted.

(c) Evaluate the effects of social and economic factors on dairy productivity among male and female smallholder farmers.

1.4. HYPOTHESES TESTED

The following hypotheses were tested:

(a) The dairy performance (production and productivity) in female-headed farm households is not significantly different from that in male-headed farm households.

(b) The dairy performance (production and productivity) in female-managed smallholder dairy farms is not different from that of male-managed and/or jointly managed dairy farms.

(c) The dairy performance (production and productivity) of the fodder plants technology (and zero grazing technology) adopters is not significantly different from that of the non-adopters in smallholder dairying.

(d) Differences in dairy productivity between farms can be explained by the social and economic attributes of the farm household, such as income, access to and tenural status of the factors of production, access to support services and markets and control over output that impact on gender issues.

1.5 ORGANIZATION OF THIS THESIS

This thesis has five chapters. Chapter one begins with a brief overview of the subject under investigation. It gives the problem statement, the justification, the objectives of the study and the hypotheses tested.

Chapter two presents the literature review, focussing on a review and a critique of the gender factor in agriculture and the works relevant to the gender dynamics and implications for dairy production and productivity. Chapter three is on methodology. It describes the conceptual framework; the survey and the econometric methods used in the analysis and a description of the study area. Chapter four gives the results of the analysis, together with the discussions, focussing on the results of the descriptive analysis followed by the regression analysis results. Chapter five gives the summary and conclusions made from the study, together with the recommendations.

CHAPTER TWO: LITERATURE REVIEW

2.1. GENDER IN AGRICULTURAL PRODUCTION

Gender encompasses the socially ascribed categories of male and female human beings. It includes the widely shared norms about "typical" or "appropriate" feminine and masculine characteristics. The norms are what we think about how women and men should behave in various situations (Royal Tropical Institute, 1995). This state of affairs results in some tasks being classified as men's work and others as women's work.

In the past, women were traditionally associated with reproductive roles and the general care of the "home". Men were expected to provide economic and general security for the whole household. These gender roles have changed over time. Male outmigration for wage labor however has increased the workload for, and the responsibilities of other household members especially women. Their roles have gone beyond what generally was expected of them by society. Studies by Bryson (1981) and Cloud (1988) indicate that this does not necessarily lead to greater cash income for the women nor to the recognition of the work they do. In the past, women household heads were a rare phenomenon. A woman whose husband had died was "inherited" by another man from the community, thereby filling the household head's roles. At present, many widows become heads of households. There are also single mothers who have never been married or who have married and divorced (or separated). These are heads of their households, and major decisions regarding the overall welfare of the household members rests squarely on them. The other household members accept their authority. The scenario of female-headed and male-headed households is thus

common. The households own various enterprises in agriculture. These enterprises are under the management of either a male or female household member. As such, there are male-managed, female managed and jointly managed farm enterprises. The female-managed enterprises can either be *de facto* or *de jure.* For dairying, just like in other farming activities, a *de facto* female-managed dairy enterprise is one where the male spouse is usually away from the farm for a time and comes back occasionally. In his absence, she makes most of the daily dairy farming decisions. Major decisions are deferred until the husband, who is the household head comes back. A *de jure* female-managed dairy enterprise is one where the husband is totally absent from the farm and the woman, besides being the household head, in most cases manages the dairy enterprise singly. A survey of the available literature reveals some confusion and a mix-up of the two levels (headship and management levels) of characterization. In some studies, there is clearly no delineation of the various types of management of farm enterprises from the household headship. It becomes hard to determine whether the researcher was investigating headship of households or management of the enterprises. A better way is to understand that the households and farm enterprises are varied in many dimensions. This includes the level of characterization and the level of authority of the leader. Characterization begins with households, and at a lower level there are the farm enterprises. Usually, the household head wields more power than the enterprise manager does.

Gender plays a crucial role in access to and ownership of assets within a household. Men often have greater access to and ownership of resources than women. Available literature on Kenya's situation shows that this stems from the past process of colonialism and commoditization. The well-documented colonial tendency to vest control of resources (land,

cash crops, wage labor) in individuals, almost always males, did much to undermine the economic position of women (Davidson, 1988; and Fleuret, 1988). Moreover, since independence, this trend has continued in most development efforts (Guyer, 1986). Men have continued to occupy a more advantaged position in farming and this is revealed in many cases where extension services have been directed exclusively at males who are assumed to be the farmers.

The consequence of this phenomenon is that, women have remained invisible from the planning, appraisal, implementation and evaluation of many agricultural development policies and programs despite the increasing importance of women in smallholder agriculture. This results in losses in potential productivity gains and economic growth, because a large proportion of participants in the sector is sidelined. The following factors have compounded the existence of this scenario in the face of the enormous positive changes in the importance of female labor and managerial ability in the structure of sub-Saharan agriculture:

(I). Crucial data about women producers are not collected and made available to agricultural planners and policy-makers. This is because currently the collection and/or the analysis and presentation of most types of agricultural data is still not gender-segregated. Therefore, in most sub-Saharan African countries, national statistics do not exist on such basic issues as:

(a). The amount of land cultivated (but not necessarily owned) by men and women farmers by province and district.

(b). The types of crops men and women cultivate, the amounts they produce, and the amounts of different crops they market in formal and informal markets.

(c). The type and number of livestock owned by men and women farmers.

(d). The agricultural tasks performed by men and women farmers.

(e). Men and women farmers' access to agricultural extension, training, inputs, credit, technology and membership in agricultural co-operatives and farmers' organizations (Adepoju and Oppong, 1994).

(II). The persistent idea of the farm household as a homogeneous unit headed by a man and encompassing one productive unit towards which all members contribute their resources (Udry *et al*, 1995).

(III). Women cultivate, but do not own land. The fact that, in most societies, men hold the land ownership titles reinforces the stereotypical image of men as the farmers and women as their assistants.

(IV). The basic notion that work should be allocated on the basis of gender and, therefore, that some tasks are particularly suitable for women and others for men is deeply embedded in tradition and custom. For example, in sub-Saharan African countries, women are assumed to be principally responsible for work associated with reproduction and the maintenance of the family (childcare, cooking, fetching water, etc.), and men with the control over family assets (land and money) and the overall production for the family. This has presented women as the 'silent partners' in

agricultural production (Mullins, 1995), despite the overwhelming evidence indicating a change in gender roles (Boserup, 1970). Therefore policy makers are provided with deficient information upon which they act to generate unfavorable policies that have impacted negatively on the agricultural industries. Most projects are known to be too macroeconomic in scope, ignoring the reality of life at the village and household level, thereby worsening agricultural production and income levels of women farmers (Due and Gladwin, 1991). Gender differentiated analyses can provide a wider understanding of gender issues, and of the role of women in agriculture and food security.

The challenge to include women in development was first taken up at the 1975 World Conference on Women in Mexico and again in Copenhagen in 1980. In the wake of the UN Decade for Women (1975-1980), many international initiatives have since contributed to a greater recognition of women's key participation in rural and other domains of development. The 4th world Conference on Women, held in Beijing in 1995, reconfirmed a global commitment towards the advancement of women. Previously, whenever women were targeted as beneficiaries of projects, it was generally in their reproductive capacity or as targets of welfare intervention (FAO, 1997). Currently, many governments and agencies have women-in-development units and gender policies and specialists. Effective women's organizations for instance, the Kenya Professional Association of Women in Agriculture and Environment (KEPAWAE), Winrock International and Federation of African Women Educationalists (FAWE) are helping female farmers gain better access to quality education, credit and resources.

Over the last two decades, a considerable body of literature on gender with respect to agriculture has been built up covering a wide range of topics. The work by Saito *et al* (1994) addresses the role of women in crop production in Kenya, Nigeria and Burkina Faso. The findings of the study indicate that women have a disadvantaged access to crop production inputs and support services, including extension. This consequently depressed the crop output in these areas by more than 20 per cent. Saito's work underscores the futility of trying to improve the overall agricultural productivity without considering the circumstances of the women farmers. That study emphasizes the need for capturing the concerns of the woman farmer besides that of the man farmer. This would help policy makers in designing procedures for availing extension and credit so that both female and male farmers rather than male farmers alone benefit. The study advocates for the need to ensure food security through increased and sustained agricultural productivity in sub-Saharan Africa. The study, however, does not cover livestock and, more importantly, dairy farming as a subset of the wider circle of agriculture. Improved dairy productivity, just like crop productivity, is crucial to ensuring food security in the region, especially given that it can cater for dietary protein needs of the vulnerable young people in the populace (World Bank Report, 1992).

Udry *et al's* (1995) work on gender differentials in farm productivity also addresses agronomic issues amongst households in Burkina Faso. The study acknowledges the great heterogeneity existing within African households, where the individuals carry out their activities on different plots and compete as well as co-operate in their actions. The study found that households were inefficient in the allocation of resources on the farms to the level that their output could be increased by 10 to 15 per cent through proper re-allocation of the currently used factors of production across fields. The male-managed plots had more factors

of production than the female-managed plots, and yields could be increased through reallocation of the resources among the plots. Further, it was found that though women had access to much smaller plots, they achieved much higher values of output per hectare than men did. However, Udry's assumption of given technology was unrealistic when it is known that access to agricultural production factors (technology included) varies between genders. That study does not also escape the trap of sidelining livestock as a sub-sector of agriculture, whose increased productivity is crucial to food security in the region.

2.2 GENDER IN SMALLHOLDER DAIRY

Much of past research on women in livestock production in Kenya focused primarily on pastoralists, e.g., the Borana and the Maasai (Bekure *et al*, 1991), whose production systems have very different objectives, strategies and organization from those of the crop-livestock systems found among the sedentary farmers. Exceptions exist in the works of Chavangi and Hansen (1983), Maarse *et al* (1995), Mullins *et al* (1996), and Inoti *et al* (1994). Apart from Chavangi and Hansen's work, the other three address the issue of the impacts of intensive dairy production on smallholder women's farm income, diets, workload and general welfare of the household members in the various regions of the country.

The work by Chavangi and Hansen evaluates the role of women in livestock production with emphasis on dairying in the western region of Kenya. The study found that women provide 85 per cent of the labour input in dairy in Western Kenya. However, only 20 per cent of the women farmers singly control the household dairy income, while 27 per cent conceded that they jointly controlled the dairy income with their husbands. Fifty three per cent of the women indicated that their husbands had exclusive control over the income generated by the

dairy enterprises, irrespective of who was the active participant in the enterprise. Chavangi notes that even increases in milk prices did not trigger the expected increase in milk production because the female dairy operators (who formed the majority of the active participants in the enterprise) were not motivated since they lacked control over the income from the dairy business.

Following on criticisms by Dwyer and Bruce (1988) on earlier literature, it is now widely recognized that household decision-making on how to utilize output from the various farm enterprises must be empirically established and documented for specific domains rather than simply assumed from Western models. This is especially true in Africa, where husbands and wives often have separate sources of income and different expenditure patterns. The Western models assume that households have a common pool where husbands and wives contribute their income for the common benefit of all household members (Udry *et al*, 1995). In this case, it does not matter who in the household, receives and controls income from the various sources, since everybody depending on his or her level of input contribution (human labor) will utilize it. Chavangi and Hansen's finding is crucial and it needs corroboration from studies in other geographical locations within the country. Another study in a different geographical location in the country would conclusively confirm or dispute this situation. The present study done in Embu District sought to find whether the same pattern exists in Eastern Province i.e., whether the dairy enterprise managers' control over income from dairy positively affected dairy productivity. The eastern region of the country bears a relatively distinct variation from the western region in terms of the people's customs and overall social setup. For one, the people of the Western region prescribe to extended families and they freely give out agricultural produce to their less privileged

relatives without asking for anything in return. Even the commercial level of the dairy subsector in the eastern region appears more advanced than that in the western region. A strong positive linkage between the active participants' control of dairy income and the performance of the subsector could be a strong point for advocating for tenural rights by the active participants, over dairy output. This can be considered in policy formulation for stimulating increased dairy productivity.

The studies by Mullins, Maarse and Inoti were a collaboration between the National Dairy Development Project (NDDP), the Ministry of Agriculture, Livestock Development and Marketing (MoALDM), the Kenya Agricultural Research Institute (KARI) and the International Centre for Research in Agro-forestry (ICRAF). The objective of these studies, which were done at the Coast Province, Vihiga District and Kiambu District, was to investigate the welfare impact of the zero-grazing dairy technology package on women and their families. The findings indicated that intensive dairying (through adoption of the zero grazing dairy technology) had led to improved household welfare primarily through increased household income and improved milk intake by the household members. However, these gains were achieved at the expense of more work for the women farmers. The studies focused principally on the zero-grazing dairy technology adopters to the exclusion of the non-adopters. There would have been a need to make a comparison between the adopters and the non-adopters of the technology at the same time. This would work to eliminate any other causes of change in the socio-economic lives of the adopters besides the adopted technology.

2.3. DAIRY PRODUCTIVITY: THE ROLE OF TECHNOLOGY

The strong demand for dairy products occasioned by increasing urbanization and income growth is a strong case for the development of smallholder dairy farming (Omiti and Muma, 2000). Several organizations, both international and national, including the Ministry of Agriculture and non-governmental organizations, have developed and promoted the use of improved dairy technologies to help increase dairy productivity and smallholder income. Dairy productivity in this case was taken to mean the average milk yield by a dairy cow per day on a farm. Though conventional farm management takes the calf as the main output in livestock husbandry and milk as the secondary product (Crotty, 1980), the practical situation on the ground is the reverse. Milk is greatly valued as a source of income and protein in many smallholder dairy farms. In most of the households, the calf is either sold at the earliest possible age or is slaughtered depending on its sex. This leaves milk as the main item in the dairy subsector. Statistics indicate that there has been an increasing trend in milk production in the country over the years (Fig. 1).

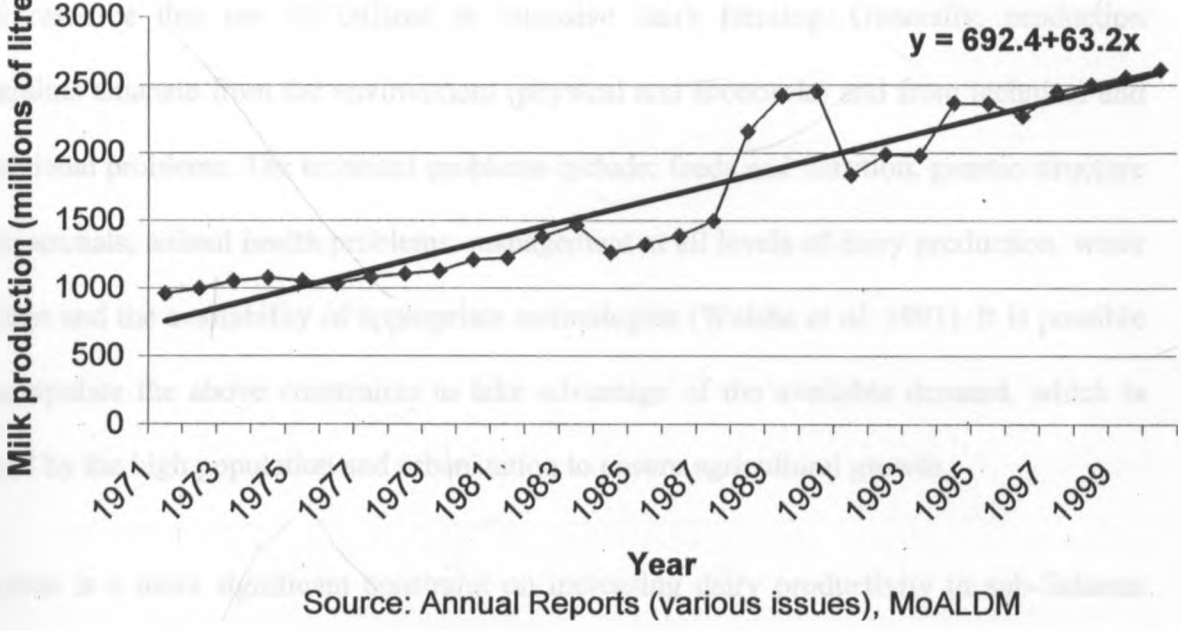


Figure 1. Trends in milk production in Kenya (million litres)

The apparently favorable state has resulted mainly from increased numbers of animals rather than higher productivity (Walshe *et al*, 1991). This, of course, is unsustainable; given the competition for space the dairy livestock are getting from exploding human population and crop farming. Productivity growth in the agricultural sector is essential if agricultural output is to grow at a sufficiently rapid rate to meet the demand for food and raw materials that typically accompany urbanization and industrialization (Christensen, 1979; Okello, 1994). Productivity growth, especially in agriculture for the developing countries, is important because it is one of the two fundamental sources of larger income streams; the other being savings, which permit more inputs to be employed (Fulginiti and Perrin, 1998). As countries like Kenya develop, urbanization (and industrialization) and high population growth should be viewed positively as opportunities to raise dairy productivity, rather than being seen as

constraints. High population represents increased demand for agricultural produce and a labor resource that can be utilized in intensive dairy farming. Generally, production constraints emanate from the environment (physical and economic) and from technical and institutional problems. The technical problems include: feeds and nutrition, genetic structure of the animals, animal health problems, management at all levels of dairy production, water shortage and the availability of appropriate technologies (Walshe *et al,* 1991). It is possible to manipulate the above constraints to take advantage of the available demand, which is created by the high population and urbanization to ensure agricultural growth.

Nutrition is a more significant constraint on increasing dairy productivity in sub-Saharan Africa than is the genetic potential, though there is a strong interaction between 'dairy merit'

and the economics of feeding (Walshe, *et al*, 1991). Natural tropical pasture has been the principal source of roughage for dairy animals for a long time, but is inadequately nutritious (McDonald, 1975, Vicente, *et al*, 1974) and would rarely support milk yields of over 3 to 4 kg per cow per day under open grazing. Cultivated forages can sustain 8 to 10 kg per day under good feeding and management conditions. Dairy concentrates are also comparable to the improved forages, though slightly better, especially in the tropics where the natural pasture quality is low (Barghout *et al*, 1990).

The commercial dairy meals command higher producer prices and which are out of reach for the sub-Saharan African smallholder farmers. The farmers can only afford simple (but safer) dairy products at low prices. Research has not fully explored the possibilities of manufacturing these appropriate commercial feeds, though farmers indicate it to be a viable option

A number of improved fodder plants have been identified as suitable substitutes to commercial dairy meals. Through on-station experimentation and on-farm trials, it has been consistently proved that these plants can offer similar nutritive value as the commercial dairy meals (Feldstein *et al*, 1990). The tree fodders are more appealing than the others because of their deep-rooting system, which makes them to continue producing well into the dry season. A number of disadvantages associated with the fodder plants pose the greatest constraint to their use by the farmers. For one, many of them have got anti-nutritive factors. These include thorns, spines, toxic amino acids (mimosine and canavamine), cyanogenic glycosides and alkaloids. Leucaena psyllid (*Heteropsylla cubana*), an aphid, has devastated *Leucaena leucocephala* all over the country to an extent that it is no longer considered a fodder tree option (Paterson *et al*, 1996). A summary of the improved fodder plants available for the smallholder farmers in the country is given in Table 1. *Calliandra calothyrsus* offers the best option out of the many. It does not have many known pests. Except for a high lignin content, it does not have poisonous chemicals.

Table 1 Characteristic composition of various fodder plants growing in several parts of Kenya.

Name	% Nitrogen	% Crude fiber	% Lignin	% digestibility	Poison present
Calliandra calothyrsus	3-3.5	25.4	11	65.9	-
Leucaena leucocephala	3-4	20.9	1.5-2.5	76.5	Mimosine
Sesbania sesban	3-4.5	26.6	-	71.4	Canavamine
Medicago sativa[1]	2.5-4	-	-	60-70	-
Trifolium semipilosum[2]	2-5	-	-	-	-
Desmodium trifolium[3]	2-3	-	-	-	-
Gliricidia sepium[4]	3-5	14.4	-	77.5	Flavanol, phenols

[1]Lucerne, [2]Kenya White Clover, [3]Three-flowered beggerweed, and [4]Gliricidia

Source: Franzel *et al*, 1996, and Mannetje *et al*, 1992).

Calliandra calothyrsus has emerged as the fodder plant of choice in many parts of the country. However, no matter how attractive it appears, danger is always involved in placing total reliance on a single species, whether it is a crop or a fodder. Therefore, there is need for diversification in the fodders to minimize risk and capture the advantages presented by the differential nutrient composition of the plants.

Production of the improved fodder plant technologies alone is not enough to ensure improved dairy performance. Extension services are required to ensure that the technology gets to the end-users that are mainly the smallholder dairy farmers. The farmers are either household heads or managers of dairy enterprise. It has often been hypothesized that new agricultural technologies could have an adverse impact on women farmers (Boserup, 1970). This is because the potential to increase labour demand from women associated with the technology could hinder them from adopting the improved technologies, e.g., *Calliandra calothyrsus*. As a result, they will miss out on the anticipated positive impact on dairy productivity. In turn, this would manifest itself in terms of gender differentials in dairy production and productivity in any location.

2.4.Measurement of Gender Differences in Agricultural Productivity

Productivity measurement and analysis in the past has traditionally been based on an index number approach (Hayami *et al*, 1970, Hayami *et al*, 1980, Kimenye, 1984 and Okello, 1994). Using this approach, output and various factor input indexes were obtained through aggregation procedures. Output index was then divided by each factor input index (to get partial productivity index) or by the sum of all factors index (to obtain total productivity index). The use of partial productivity indexes as measures of production efficiency as

assumed *apriori* was found wanting, making it necessary to rely mostly on total factor productivities (Fabricant, 1959). Total factor productivities were also found to be riddled with shortcomings. For one, it was found that not all of the output could be explained by changes in the conventionally defined inputs even after adjusting for improvements in input quality (Griliches, 1971). In other words, identifying all the factors determining the output was impossible, leaving an unexplained portion of output which could only be explained by omitted unconventional factors.

The story has not been made any easier with the realization of the importance of gender as a variable in agriculture. Differences in farming systems and social and cultural institutions complicate the measurement of gender differences in agricultural productivity. Ideally, an evaluation of gender differences in agricultural productivity should be based on estimates of total factor productivity, in which an index of output is divided by an index of inputs aggregated over all types of outputs and inputs, respectively (Quisimbing, 1995). However, besides aggregation problems, lack of gender-differentiated data on inputs and output has prevented the use of this approach. Therefore most of the existing studies use partial productivity measures, such as yield or labor productivity. In livestock production, Upton (1993) advocates for the use of partial productivity indexes in assessing the performance of livestock projects. Instead of using the conventional factors of production (land, labor and capital), the ideal measure should be livestock units, whereby the partial productivity measure should be taken as output per livestock unit. Other input requirements like labor, water or space are likely to closely related to the number of livestock units, so this remains a useful general measure of the size of the enterprise. However, measurement of a livestock unit is only but an estimate.

The present study targeted on milk as the output from dairy as opposed to multiple outputs from a livestock enterprise within a household. Since the animals were lactating crosses with comparable sizes, the number of cows rather than livestock units was adopted in measuring dairy productivity. Therefore, dairy productivity was taken to denote the amount of milk produced daily per cow within a farm. Dairy production was a measure of the total amount of milk produced per day from a farm. This was included in the analysis to try and quantify the milk rewards to the farmer from the existing dairy unit given the *status quo*.

CHAPTER THREE: METHODOLOGY

3.1. CONCEPTUAL FRAMEWORK OF THE STUDY

The primary objective of this study was to assess the performance of dairy farming among male and female smallholder farmers in the light of efforts to encourage them to adopt improved fodder plants. The study also aimed to determine the socio-economic factors that influence the differential performance among the farmers. This involved determining dairy productivity and dairy production for male-headed and female-headed households at one level and that of male-managed, female-managed and jointly managed dairy enterprises at another level. Dairy productivity was taken to mean the amount of milk yield in litres per day per cow from a farm. Dairy production represented the total amount of milk yield in litres from a farm in a day.

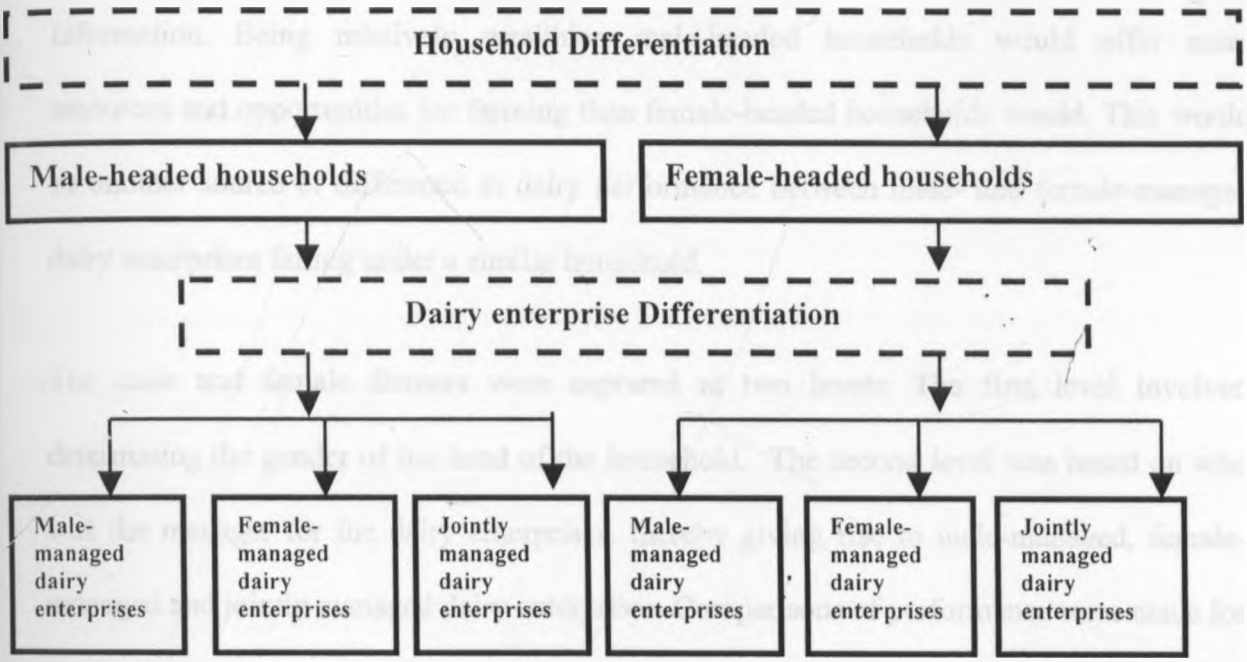
The following propositions were posed for examination:

(a) Smallholder dairy performance for farms under male farmers and for those under female farmers differs significantly.

(b) The performance of smallholder dairy in farms under male and female farmers who have adopted improved fodder plants technology is better than those farms under male and female farmers without the technology.

(c) The socio-economic environment is a strong determinant of smallholder dairy performance.

The need for categorizing the farmers as male or female in the analysis arose from the fact that they face different circumstances and opportunities in their farming environment because of their gender. This would be reflected in the performance of the dairy activities they handle. Figure 2 shows the classification of households and dairy enterprises into various categories under male and female farmers.



Note: Author's work, 1999

Fig. 2. Classification of households and dairy enterprises under male and female farmers.

Male dairy enterprise managers from male-headed households face different opportunities and constraints from those under female-headed households. Similarly, female dairy enterprise managers from female-headed households face different opportunities and constraints from those under male-headed households. It has been indicated that male-headed households in tropical Africa are endowed with more resources on average than female-headed households (Saito, 1994), a situation that would create disparities in dairy

performance based on which category of household the dairy enterprise falls under. Thus, one would expect a female farmer from a male-headed household to have greater access to resources and hence do better than one from female-headed household, e.g. extension services in the past have been in favor of male-headed households as opposed to the female-headed households (Boserup, 1970). Female farmers from such farms are less disadvantaged than female farmers from female-headed households in terms of access to technology and information. Being relatively wealthier, male-headed households would offer more resources and opportunities for farming than female-headed households would. This would be another source of difference in dairy performance between male- and female-managed dairy enterprises falling under a similar household.

The male and female farmers were captured at two levels. The first level involved determining the gender of the head of the household. The second level was based on who was the manager for the dairy enterprises, thereby giving rise to male-managed, female-managed and jointly managed dairy enterprises. Comparisons of performance were made for the farmers at the household level then at the dairy enterprise level to cater for the first two propositions. This offers a more realistic situation of the smallholder rural farming as opposed to assuming the household head is the same as the dairy enterprise manager. A Cobb-Douglas production model was then estimated for the individual divisions at each level.

3.2. ANALYTICAL PROCEDURES

Two analytical procedures were used in the analysis. The first, descriptive statistical analysis was used to generate results that facilitated the comparison of dairy performance amongst male and female smallholder dairy farmers. The other, the production function analysis was used to determine the socio-economic factors that are crucial in determining the level of performance of the dairy enterprises.

3.2.1. DESCRIPTIVE ANALYSIS

The method involved the use of frequency distributions, mean calculations, percentages and cross tabulations. The procedure was important in analyzing the distribution of the various households and types of dairy enterprise. Various aspects of dairy performance were evaluated. The analysis was done with a view of assessing the comparative objectives. The comparisons were assessed by use of the T-test and the F-test, and the results depicted graphically and by use of tables.

3.2.2. PRODUCTION FUNCTION ANALYSIS

The production function analysis shows the technical relationship between inputs and output. This relationship is expressed as:

$Y = f(X_1, X_2, X_3\text{----------}, X_n)$

Where: Y = output and X_1,------,X_n are the inputs.

Among the various production functions used to study agricultural productivity, the most

commonly used is the Cobb-Douglas production function (Gujarati, 1978. Jamison *et al*, 1982). Production functions define the production possibilities open to the producer by considering how the inputs affect the output (Dillon and Hardaker, 1988).

Although production functions offer a strong policy recommendation tool, observations by Heady and Dillon (1961) indicated that production function results cannot be used to make specific recommendations. This is because of the major problems associated with specification of the function, aggregation of the inputs and output, and estimation, which are inherent in the functional form.

Despite these limitations, production function analyses are useful in studies planned for general diagnostic purposes. Dillon and Hardaker (1980) conclude that production function analysis, when combined with other micro-and macro-economic analyses, can be quite useful for extension and policy recommendation purposes.

3.2.2.1. MODEL SELECTION

The models used in the estimation of production functions can take different forms. These include the linear function, the quadratic function, the translog function, the square root function, the semi-logarithmic function and the power or Cobb-Douglas function, just to mention a few.

There is no magic rule that will tell us which is the most appropriate model to employ for a given empirical problem. An objective assessment of the relative merits of the alternative functional forms can be made possible by considering (a) economic theory and (b) statistical

tests of goodness of fit. However, none of these criteria provides a clear and unambiguous guidance, and in most cases, choice of functional form is inevitably somewhat arbitrary (Upton, 1989). As Kilungo (1999) puts it, the problem is usually watered down to striking a balance between simplicity and sophistication.

Dillon (1977) and Hu (1974) consider a number of features that should dictate a good model. These include:

(1). A combination of statistical measures of goodness of fit e.g., coefficient of determination (R^2), and the adjusted R^2, the F-ratio value, statistical significance and the signs of the estimated regression coefficients

(2). Biology and economics of the response process under investigation

(3). The subjective judgement and computational ease.

The above guidelines or partial criteria cannot resolve the deep problem of choice, although they may go some way toward narrowing down the range of choices in a rational way (Goldberger, 1968). Different forms of functions estimated from the same set of observations can also lead to vastly different conclusions (Upton, 1989). Therefore, no critique-proof recommendations can ever be made from the analysis employing one function alone.

Agricultural production activities, including dairy production, do not reflect linear relationships between inputs and output, except in situations where the input factors are all used in very small levels. This rarely happens in a multiple factor situation. Therefore, by

use of this criterion alone, the linear model was not selected. Two summary statistics (R^2 and adjusted R^2) were used to determine the goodness of fit with respect to the various models and the available data. A goodness of fit measure is a summary statistic indicating the accuracy with which a model approximates the observed data. The two summary statistics are discussed below:

(i). R^2, the coefficient of multiple determination

This is the proportion of the total sum of squares of the dependent variable around its mean that is explained by the regression. The disadvantage of using R^2 as a summary statistic for comparing regressions is that it can be increased by simply adding more independent variables, a feature that is undesirable.

(ii) Adjusted R^2.

This was proposed by Theil (1961), as a criterion for choosing between competing regression models. It is the coefficient of multiple determination adjusted for degrees of freedom. Adjusted R^2 can decrease if the additional independent variable does not increase the goodness of fit substantially. It offers some protection against choosing a regression that includes indiscriminately a large number of independent variables. Thus the Adjusted R^2 rather than R^2 was applied in model evaluations.

The selection criterion relied heavily on the goodness of fit and the authenticity associated with the model in natural agricultural production circumstances. On this basis, the Cobb-Douglas production function was chosen for the purpose of regression analysis. The Cobb-

Douglas production function has the following merits over the other functions:

It makes it possible for diminishing marginal returns to occur without losing too many degrees of freedom, implying that the Cobb-Douglas function is an efficient user of degrees of freedom.

It is simple and has computational feasibility. Its regression coefficients give the elasticities of production, where the elasticity of production is defined as the percentage change in output level resulting from a one-percent change in the level of input, *ceteris paribus*. These elasticities are independent of the level of inputs.

The Cobb-Douglas functional form is in addition more versatile and can capture the inherent properties of many other functions.

In view of the above advantages, the Cobb-Douglas function was used in this study to estimate the dairy production and dairy productivity functions. The Cobb-Douglas functional form according to Wonnacott and Wonnacott (1970) is usually specified as:

$$Y = AX_0^{\beta o\, o} X_1^{\beta 1}\, X_2^{\beta 2} \text{ ----------} X_n^{\beta\, n}\, \mu.$$

Or

$$Y = A \prod_{i=n}^{n} X_i^{\beta_i}\, \mu$$

Where the Y and the X_is are output and inputs, respectively, the β_is are the parameters and μ is a multiplicative stochastic error or residual term This was linearised into:

$$\ln Y = \ln A + \beta_0 \ln X_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \ldots + \beta_n \ln X_n + \mu$$

Or

$$\ln Y = \ln A + \sum_{i=n}^{n} \ln X_n + \ln \mu$$

The expression of Y in natural logarithmic form makes it possible for the analyst to use the least squares estimation method by employing the assumptions that the residual error term is independently distributed from one farm to another with a mean of zero and a finite variance.

Despite the widespread use of the Cobb-Douglas production function, there are some limitations associated with it. For example, the use of the power function has been found to be unsatisfactory especially where there are ranges of both increasing and decreasing marginal productivity or in the case of both positive and negative marginal productivities. In addition, the Cobb-Douglas function assumes a unit elasticity of substitution between factors and it does not reach a maximum level of output implying that, as you increase the level of input, output increases indefinitely. With undefined economic optimum, the function may over-estimate the input, which equates marginal revenue to marginal cost.

A number of studies have employed the Cobb-Douglas model as an analytical tool, pointing to its popularity. Keith *et al,* (1957) used and recommended the Cobb-Douglas mathematical

form for explaining milk production. Looking at the labour input in milk production, Keith (1963) adopted the Cobb-Douglas production function because it accommodates diminishing marginal returns and dummy variables.

3.3 THE STUDY AREA

The study focused on an assessment of differences in dairy production and productivity on the basis of gender taking into account the socio-economic conditions of the dairy farmers in the unique household environments under which they operate. The study was conducted in Runyenjes and Manyatta Divisions of Embu District. These divisions form the part of Embu District where improved smallholder dairy is a major component of the land use system. Also, the two divisions fall within the National Agroforestry Research Project's (NARP's) mandate area for applied research and transfer of the improved fodder trees.

Embu District, one of the twelve administrative districts of Eastern Province, covers an area of 708 square kilometers. It borders Tharaka-Nithi, Mbeere and Kirinyaga to the North, East and Southeast, and West respectively. It lies approximately between Latitudes 0^0 8^1 and 0^0 35^1 South, and Longitudes 37^0 19^1 and 37^0 42^1 East. It is divided into five Divisions, viz. Manyatta, Runyenjes, Kyeni, Nembure and Central. The divisions are made up of fifteen locations and 32 sub-locations (See Figure 3).

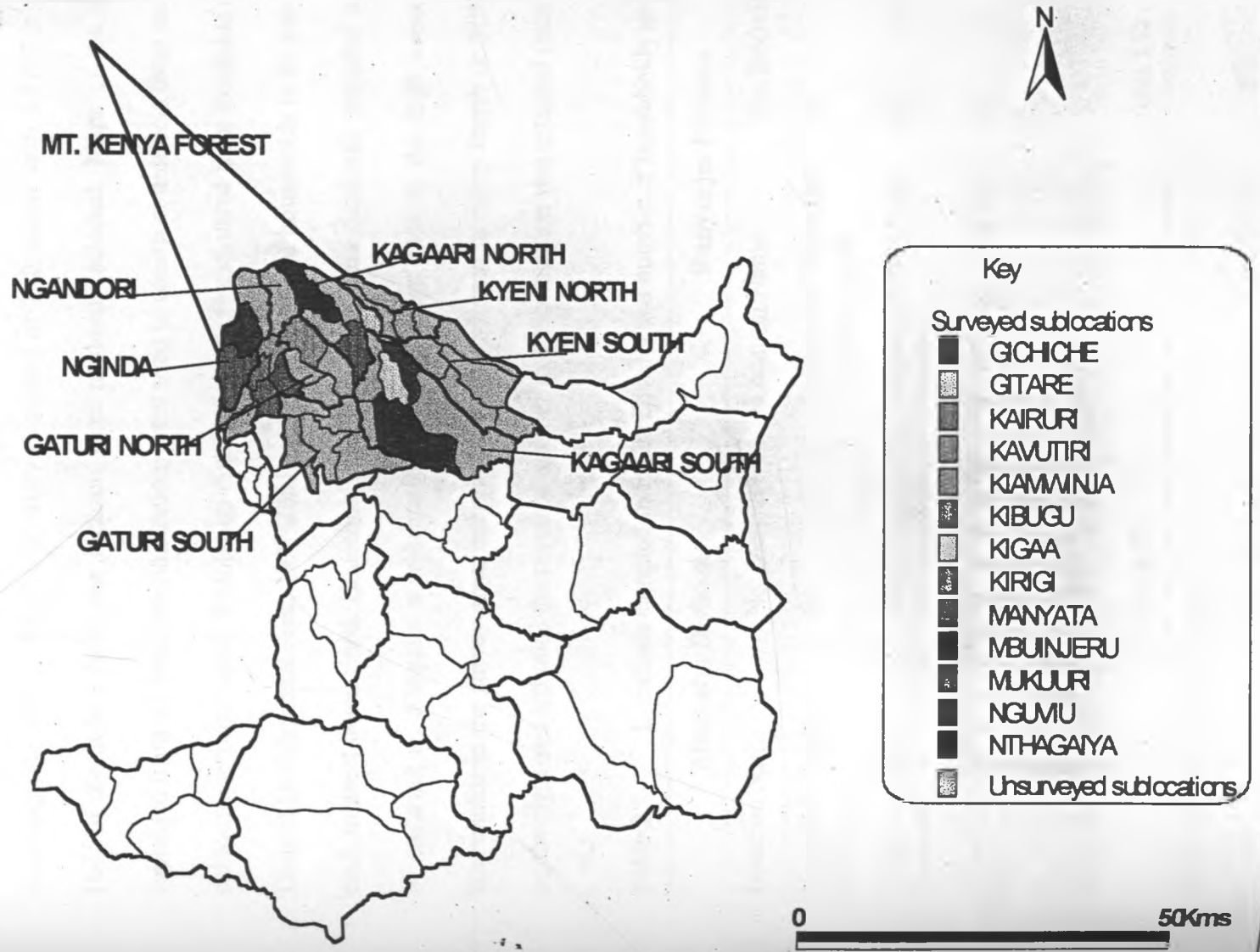
Embu has a population of approximately 291,000 persons with about 50,000 farm families distributed almost evenly, save for the Northwestern extremity where the population density is low and scattered over a large area. The most noticeable physiographic features of the district are Mt. Kenya in the northwestern horn, a range of hills in the southwest and river

Tana in the west. The local language is Kiembu, a close relation of the Kikuyu language from the Central Province of Kenya. Most of the district is high potential with average rainfall amounts of about 1000mm/year. A small portion in the southern region can be considered as range or semi-arid, while the northwestern horn (extremity) is montane. From Mt. Kenya to the lower region bordering river Tana, crops grown (systematic order) include: Tea, Tea/Coffee mixture, Coffee and Maize and Beans

Dairying is widely practiced as you move up the higher cooler parts of the North. Grade cows and crossbreeds are kept in basically all parts of the district under zero grazing, save for the drier south where the local zebu are kept under open grazing system. Runyenjes and Manyatta divisions, which formed the study area, lie within the high potential agro-ecological zone. They cover the portion of Embu District where smallholder dairying is a major component of the land use system (Jaetzold and Schmidt, 1983; Embu District Development Plan, 1997-2001).

Fig. 3

Embu - Surveyed Sublocations



3.4. THE SAMPLE

A total of 301 smallholder dairy farmers in Embu District were interviewed by use of a semi-structured questionnaire. The households were selected through a systematic random sampling procedure. The area of study consisted of 2 divisions with a total of 7 locations. Half of the sublocations per location were randomly selected. Maps of the sublocations (obtained from the local administration) were used to construct transects from one end of the sublocation to the other. Population distributions were estimated from available data (Embu District Development Plan, 1997-2001), and the number of households to be surveyed along each transect determined. Households along transects were randomly sampled with the aim of ensuring an adequate representation of dairy farms. Due to the high concentration of households in the survey area, interviews were conducted in every fourth or fifth household on the right and left until the required number in a sub-location was attained (table 2).

Table 2: Locations sampled in Embu District and number of households interviewed

Manyatta Division		**Runyenjes Division**	
Location Name	No. Interviewed	Location Name	No. Interviewed
Ngandori (3 sub-locations)	64	Runyenjes Township (3 sub-locations)	59
Ruguru (2 sub-locations)	32	Kagaari North (2 sub-locations)	46
Nginda (2 sub-locations)	32	Kagaari South (2 sub-locations)	46
Gaturi North (1 sub-location)	22		
	Total 150		Total 151

Note: Author's survey 1999.

Purposeful (a sampling procedure where the researcher is looking for a sample with peculiar attributes) random sampling procedure was employed. A household to be interviewed had to have at least a lactating cow and a mature person involved in the day-to-day management of the dairy enterprise. The households were classified as male-headed or female-headed. The dairy farms were categorized into male-managed, female-managed and jointly managed dairy enterprises.

3.5. DATA COLLECTION

The information collected was made up of primary data. Some specific variables for which data was collected included: (a) Land, (b) Labour, (c) Capital, (d) Household characteristics, (e) Market and institutional factors, (f) Other factors, for instance, the lactation stage of the cow.

Information for questionnaire preparation was obtained through a minor Participatory Rural Appraisal (PRA) conducted in Manyatta and Runyenjes Divisions. The information collected was also used as an important constituent of the primary data that was collected through the formal interviews that were done later. The PRA was executed in conjunction with the District Agricultural staff and the local leaders. The tools utilized were mainly:

(a). Historical timelines and trend lines: to obtain a list of key events in the community's dairy farming life that would help identify past trends, events, problems and achievements.

(b). Seasonal calendars: to help identify cycles of activity relevant to dairy farming that occur within the life of the community on a regular basis, and determine whether there are

common periods of excessive environmental problems (stress) or opportunities over the course of a normal year.

(c). Institutional analyses: to learn about the activities of the various groups and organizations dealing with the dairy industry within the community, understand how the community views these organizations and how they rank them according to community perception of their contribution to dairy development and assess the relationships among the organizations.

(d). Gender daily calendars: to provide a clear picture of who does what in the community with respect to dairy farming.

Primary data was obtained through formal interviews with male and female farmers in the two divisions. The questionnaire was pre-tested in two other divisions (Kyeni and Nembure) and adjustments done accordingly, before the formal survey. Informal interviews were also carried out with the Ministry of Agriculture staff at the district and divisional levels. The Catholic diocese's agricultural co-ordinator's office also provided very valuable information informally. Official records of the Ministry of Agriculture at both the division and district levels were also examined. The information collected from secondary sources was mainly utilized for the following purposes:

(i). To quantify populations among sub-locations with the aim of determining the number of households to be interviewed along transects.

(ii). To confirm the authenticity of primary data collected.

3.6. THE VARIABLES

There are many factors that influence agricultural productivity. Notable among these are:

(i). Amounts of land, labour, and capital

(ii). Quality of these factors of production, i.e., fertility of the land and breed of the livestock.

(iii). Health, education and experience of the farmer.

(iv). Availability of appropriate technology.

(v). Access to extension services or contact with extension agents.

(vi). Availability of market for the produce and the prices existing in the market.

The key ones for dairy are amounts of land under fodder crops, the amount of labour available for dairy activities, capital employed in dairy, quantity of feeds available and access to extension services, among others. The gender variable becomes important in so far as there is differential access to resources and bias in control of the output amongst the farmers on the basis of gender. For this study the specific variables that were employed are given in the Table 2 below and are discussed hereafter.

Table 3: List of variables

Variable Name	
1. Land	**5 Household characteristics**
Total land area (acres)	Gender of household head (1 = male,
Land area under Napier (m^2)	0 = otherwise)
2. Labour	Years of livestock farming by household head
Family labor (No. of adult persons).	Years of formal education of household head
Male hired labor (No. of adult persons)	Controller of dairy income
Female hired labor (No. of adult persons)	(1 = farm manager, 0 = otherwise)
3. Capital	Off-farm employment household head
Market value of equipment for dairy (Kshs)	(1 = yes, 0= no)
Gross monthly income (Kshs)	Off-farm employment by household head's spouse
Money spent on feeds monthly (Kshs)	(1 = yes, 0= no)
Quantity of cut fodder per livestock unit daily (kg)	**6. Others**
4. Market and institutional factors	Livestock herd size
Milk price(Kshs/700ml bottle)	No. of lactating cows
Commercialization index	Lactation stage of the cow (months)
Distance to milk market (km)	Number of improved fodder trees on the farm
Access to credit by household (1= yes, 0= no)	Whether zero-grazing is present (1= yes, 0 = no)
Contact with extension (1= yes, 0=no)	Division (As a dummy where 1= Manyatta, 0 = Runyenjes)

3.6.1. THE DEPENDENT VARIABLES

(a). Dairy productivity

Conventional farm management regards the calf as the main product in livestock production, relegating milk to a secondary level (Crotty, 1980). As already noted, the situation in real rural smallholder farming is the direct opposite. Milk is so valued that it is the sole factor conditioning the practice of dairy farming. Literature acknowledges milk as the 'white gold' most livestock farmers are after (Falvey *et al*, 1999). The amount of milk produced per cow per day from a household was taken to denote dairy productivity. It was an important denominator in this case because it considered the farms at the same level of having one cow, on average, thereby making the comparisons in various farms more plausible. The units used to measure dairy productivity were litres of milk per cow per day per household. Saito's study, though dealing with crops, took the value of crop yield as the dependent variable. However, the physical output size was preferred to value of output, for the latter depended on price structures (of milk in this case), which were found to vary from place to place in the study area.

(b) Dairy production

A number of farmers were found to be keeping more than one dairy cow on their farms. Therefore a variable reflecting the total amount of milk yield per household per day was also employed as a dependent variable. Therefore, dairy production, denoting the total amount of milk produced per day from the farm was used. Its units were litres of milk per day per household. It was expected that farms with more lactating cows would realize higher dairy

production than those with fewer cows, *ceteris paribus*.

3.6.1.2. INDEPENDENT VARIABLES

(a) Land.

Land was differentiated into total area of land owned in acres and land under napier grass in square metres. While running the correlation coefficient matrix, it was discovered that a large total land size did not necessarily result into large areas under napier grass. It was expected that large total land area and large areas of land under napier grass on a farm would result into large dairy productivity and dairy production.

(b) Labor.

Labor was differentiated into family labor and hired male or female labor. The variable was measured in terms of adult persons involved in dairy activities within the household. Just like in many past studies, quantifying labour provided a problem. There was no distinct labor attributed specifically to dairy. At times, the laborers were found weeding the farm and gathering weeds at the same time for feeding the cows. The hired laborers were also involved in a myriad of other activities around the home despite having been employed to tend the cows. In other words, it was hard to isolate the man-hours or man-days that were utilized for dairy activities. Therefore, the number of adult persons who were involved in some dairy work was used as the variable rather than the man-hours or man-days. Based on economic theory, it was hypothesized that labour would offer a positive relationship with dairy production and dairy productivity.

(c) Capital

Capital was differentiated into the following components.

(i) Market value of all tools and equipment used in dairy measured in Kenya shillings.

(ii) Gross monthly income for the household in Kenya shillings. This included income from off-farm employment and for the cash enterprises within the household.

(iii) Total amount of money spent on commercial dairy feeds per month. This included money spent on purchases of dairy meals, bran, pollard, "magic set", salt licks and maize germ. Most of the farmers bought these items approximately on a monthly basis, hence the monthly measurement. The money spent on these goods would impact positively on both dairy production and dairy productivity.

(iv) Estimated average quantity of fodder (kilograms) given per livestock unit per day.

Irrespective of the quality and type, the total amount of cut fodder given per livestock unit per day was determined. The amount was then divided by the number of "Tropical Livestock Units" (TLU) on the farm. This gave an estimate of the amount of cut fodder available per livestock unit per day on the farm. The measure was preferred to total amount of cut fodder per day; the former is able to capture whether or not the amount fed was enough or not. One standard Tropical livestock unit was taken as an equivalent of one cow with calf or three mature goats. The more the cut fodder given per livestock unit, the higher the dairy production and dairy productivity *ceteris paribus*.

(d) Household characteristics

The household characteristics hypothesized to influence dairy production and dairy productivity were:

(i) Gender of the household head

This variable was coded as a dummy, where 1 was for male-headed households and 0 for female-headed households. *The head of the household is the official owner of the principal assets of the household and his or her decision can override any other decisions made by other members of the household. All the other household members acknowledge his or her authority as the head of the household.* In sub-Saharan Africa, male headed households are usually more advantaged in terms of resource ownership for agricultural purposes than female headed households (World Bank, 1987).

(ii) Gender of the dairy enterprise manager

This variable was similarly coded as a dummy, where 1 was for female managed dairy enterprises and 0 otherwise. The dairy enterprise managers could either be coming from male-headed or female-headed households. In cases where the manager of the enterprise was a female from a male-headed household, there were very high chances that the husband was in formal employment and the wife had been left in charge of the dairy business. Obviously, the resource base in such a household would be higher than the case where both partners were not working and the enterprise was jointly managed or as expected in such circumstances to be managed by the man (McCormick and Mitullah, 1995). The expectation

was that there was a positive relationship between the gender of the dairy enterprise manager with dairy production and dairy productivity (however, this was not the assumption *apriori*).

(iii) Years of livestock farming of the household head

This was a continuous variable calculated as the number of years the household head had owned and kept dairy cattle. At first sight, it seemed like the variable was highly correlated with the age of the household head. There were cases of farmers who had just retired from formal employment and migrated back to the countryside from the city where they had been living for years. Though their ages were high, the years they had been involved in livestock keeping were fewer than those of younger heads who had been staying in the rural areas since birth. It was hypothesized that farmers with more years in dairy farming would realize higher dairy production and dairy productivity. The expected positive relationship would be due to the fact that, with time, farmers are not only better able to assess the requirements of their animals, but are also superior in management and entrepreneurial power.

(iv) Years of education of the household head

The number of years of formal education of the household head was used. In this case, it was hypothesized that education would have a positive effect on dairy production and dairy productivity on the respective farms. Education enhances a farmer's ability to understand his alternatives, and to know when and where to buy inputs and sell the dairy outputs. An educated farmer would more likely know the market status for the dairy inputs, and therefore, adjust or even bargain with confidence for favorable prices. He may also have the

capacity for discrimination of differences in quality and may be able to better judge quality more accurately (e.g., for various brands of salt licks). Such a farmer would easily accommodate new innovations to enhance the performance of the dairy enterprises.

(v). Years of education of the spouse to the household head

This was anticipated to have the same effect as the years of education of the household head. What was important in this was that, in cases where the household head did not double as the dairy enterprise manager, the spouse was mostly the enterprise manager. This bore a relationship, therefore, to the education level of the dairy enterprise manager.

(vi) Controller of income from milk sales

This was coded as a dummy where 1 was when the controller was the dairy enterprise manager and 0 when otherwise. The dairy enterprise manager would require a free hand to handle and control the dairy income as an incentive for hard work. According to Mullins (1995), 53 per cent of women dairy enterprise managers from Western Kenya had no say on how to spend the income from milk sales. This created a situation where an appreciable increase in milk prices did not elicit any increase in milk supply as conventionally expected. Therefore the controller of milk income as a variable was hypothesized to have a positive relationship with both dairy production and dairy productivity.

(vi) Off-farm employment of the household head

A working household head was expected to contribute towards the household income and therefore make it easier for the household to have access to the resources required for the

dairy enterprise. Though his/her absence would remove his/her physical services from the household, the higher income will act to boost the dairy performance since the extra income will employ a replacement.

(vii) Off-farm employment of the spouse to the household head

As hypothesized in (vi) above, the extra income from this scenario would provide more resources for the dairy enterprise. However, most of the spouses to the household heads were expected to be the dairy enterprise managers and therefore, off-farm employment would mean that they were not always available to offer their management services on the farm. This was anticipated to impact negatively on both dairy production and dairy productivity.

(e) Market and institutional factors

(i) Price of milk

This was taken as the price of milk for the 700ml bottle (the most commonly used measure). Milk had a wide variety of buyers ranging from the co-operative societies to hotels and the occasional individual buyers. The prices varied with the buyers. Basic economic theory indicates that the higher the price, the higher the milk supply. This could be achieved through increasing the number of dairy cows or intensification of the dairy farming by the farmers. Therefore, it was hypothesized that a positive relationship would exist between this variable and dairy production and dairy productivity.

This represented the proportion of milk produced per cow in a day that was actually sold. It was taken that the availability of a raw milk market could induce farmers to realize higher milk output to capture the advantages of an available market as opposed to a limited outlet for their milk. Therefore, a positive relationship was expected to exist between this variable and the dairy production and dairy productivity.

(iii) Distance to the milk market place measured in kilometers

The distance to the milk market place was taken as the distance from the homestead to the point where the farmer usually delivers the milk, either for a co-operative van to pick it up or for the buyer to receive it. It was expected that the longer the distance the less motivated the farmer will be in producing more milk for sale. Those close to the milk selling point would have the impetus to continue producing the milk to capture the available revenue. Taking the fact that they will have to produce milk for consumption and for sale, it follows that they will have the stimulus to produce more milk to meet these requirements than those far away from the milk market. Thus a negative relationship was hypothesized in this case.

(iv) Access to credit facilities by the household

This variable was coded as a dummy where 1 implied access to credit and zero implied non-accessibility. It was assumed that a household that had taken a loan from any lending organization in the last two years, be it a bank or a co-operative society, had access. This created problems in cases where some households had potential of taking a loan for investment in dairy but had not gone for it because they had enough resources for dairying without taking the loan (understandably because of the small size of operation of the dairy

enterprise). The relationship between access to credit and dairy production and productivity was hypothesized to be positive.

(v) Access to extension visits

This was taken as a dummy where a farmer who had been visited at least once by a livestock extension officer or had attended a workshop/seminar where dairy matters had been discussed in the last twelve months prior to the interview, was represented with one. Zero represented 'otherwise' conditions. It was hypothesized that exposure to livestock extension services or other non-formal livestock education experience would have a positive effect on dairy production and dairy productivity.

(f) Other factors

Livestock herd size.

A large herd size would mean allocation of fewer resources, in general, on a per capita basis for the animals, given that the small-scale operation for the farmers was an indication of their limited resources. This would consequently depress the dairy productivity level of the dairy enterprises. Thus a negative relationship was hypothesized with dairy productivity. For dairy production the type of animals owned by the household would determine the relationship. If the herd were composed mainly of lactating dairy cows, then a positive relationship would be predicted. A negative relationship would be expected if the herd was not made mostly of lactating cows. The same would be expected if the herd was composed mainly of lactating dairy cows but highly constrained for resources.

(ii) Number of lactating cows

The number of lactating cows was expected to have a positive relationship with both dairy production and dairy productivity. It is widely documented from agronomic studies that very small-scale operators have a tendency of utilizing less of the inputs than relatively large operators. The more the number of lactating cows a household has, the higher the milk produced per day from the farm, *ceteris paribus*. Similarly, the more the number of lactating cows on a farm, the more the farmers' input levels and, therefore, the higher the dairy productivity.

(iii) Lactation stage of the cow (months)

This was taken as the number of months the cow had finished since the latest calving. The amount of milk produced per day per cow increases up to a peak then decreases afterward with time. The time taken to peak is usually short so that, in the aggregate, a negative relationship is expected between this variable and the dairy production and dairy productivity.

(iv) Number of improved fodder trees

The main improved fodder plant grown in the study area was *Calliandra calothyrsus*. This is a high protein (22 per cent) forage plant that can be utilized to ensure higher dairy production and dairy productivity. It was thus hypothesized that a positive relationship would exist between this variable and the two dependent variables. There were sporadic appearances of other improved forages, but the farmers were either unaware of their use or

they were just too few to be of any concern to the farmers. *Leucaena leucocephala*, which had been a formerly common fodder plant (initially propagated for dairy goats), had more or less fizzled out because of the leucaena psyllid (*Heteropsylla cubana*) menace and the non-acceptability by the farmers because of its bloat-causing effect (due to mimosine presence). *Sesbania sesban*, though one of the best dairy fodder plants, is concentrated in the hot humid Western parts of Kenya, and most farmers in the study area do not know it. The few who know about it lack the seed to propagate it.

(v). Zero grazing

The importance of zero grazing as a dairy performance-enhancing technology, especially in Kenya, is widely documented. The technology ensures a more closer care of the dairy animals and keeps them from mixing with others that might be infected with contagious diseases. It also acts to reduce unnecessary energy expenditure by the cows while walking around in search of feed, as is the case in open grazing. The variable was coded as a dummy where 1 represented those farms with the zero grazing technology and 0 for those farms without the technology. The variable was hypothesized to have a positive influence on dairy production and dairy productivity.

(vi) Administrative division

The study area comprised two administrative divisions, Manyatta and Runyenjes. While most of Manyatta occupies the cooler wet northern parts of the district, parts of Runyenjes appear in the hotter and less wet southern region. The greener, dairy-friendly Manyatta was coded for 1 while Runyenjes was coded for 0. A positive relationship between division,

dairy productivity and dairy production was predicted.

3.7. CORRELATION AMONG THE VARIABLES

An attempt to estimate meaningful multivariate production functions is frequently impaired by occurrences of high correlations among explanatory variables. Situations where such high correlations adversely affect both the statistical and the technological interpretations of the function are termed as multicollinearity problem. The term multicollinearity is used to denote the presence of linear relationships between (or near linear relationships among) the explanatory variables (Koutsoyiannis, 1973). The precision of the parameters is reduced by multicollinearity, and as a result, hypothesis testing becomes weak so that diverse hypothesis about parameter values cannot be rejected (Kennedy, 1985). Multicollinearity is a sample problem and as such it cannot be tested. Rather, what is testable is the degree of multicollinearity in the exogenous variables. The Pearson correlation coefficient was used to test the hypothesis of no multicollinearity between the independent variables in the correlation matrix. Kennedy (1985) states that a value of 0.8 or higher in absolute terms of one of the correlation coefficients indicates a high correlation between the two independent variables to which it refers. The variables with a correlation coefficient equal to or greater than 0.8 were removed from the analysis. Based on this criterion, the partial correlation coefficients indicated non-existence of the problem of multicollinearity in the remaining variables. The variable correlation matrix for the explanatory variables ranged from 0 to 0.7. In addition, the square roots of the standard errors of the regression coefficients were found to be less than the absolute values of the parameters. The results can therefore be accepted as unbiased estimates of the biotechnical condition.

CHAPTER FOUR: RESULTS AND DISCUSSION

This section begins with a note of the results of the PRA and descriptive analyses of the survey results. The econometric analysis through the estimation of the Cobb-Douglas production model was done for both the general and the specific households. A simulation was done to make a comparison between the female and male farmers accessible to a similar level of the dairy farming resources.

4.1. PARTICIPATORY RURAL APPRAISAL (PRA) RESULTS

The PRA conducted in Runyenjes and Manyatta Divisions of Embu District found out that the improved dairy breeds together with napier were introduced just before independence. *Leucaena leucocephala* was introduced in the 1980s as a goat fodder but because of aphid infestation (*Heteropsyla cubana*), it was wiped out to a level of becoming extinct in the region.

With time, the pure breeds of dairy cows have been declining to be replaced by cross breeds. Zero grazing dairy technology, which was introduced at the same time as the pure dairy breeds, has had an upward trend to the level that nearly every farm has got a zero grazing unit. *Calliandra calothyrsus* is a more recent introduction and though there is the enthusiasm, the adoption levels are still very low mainly because of unawareness and lack of the planting material.

In terms of who does what in dairying, it was found that most of the dairy activities, ranging from weeding fodder, feeding to milking, are in the domain of women. Men are

predominantly cash crop farmers, or they are in town working in salaried employment.

4.2. HOUSEHOLD FEATURES

Eighty four percent of the households in the study area were male-headed while 16 per cent were female-headed. The male heads appeared mainly as husbands and, occasionally, as sons of widows (especially in households where the husband died). Female heads were widows, divorcees and single mothers. Forty seven per cent of the dairy enterprises were managed by women, while 35 per cent of them were jointly managed and only 17 per cent were male-managed (Table 4).

Table 4: Breakdown of sample number of households by gender of household head and dairy enterprise manager in Embu district of Kenya (percentages in parentheses).

	Gender of household head		Total
	Male	Female	
Male managed	49 (16.2)	3 (1.0)	52 (17.3)
Female managed	99 (32.9)	42 (14.0)	141 (46.8)
Jointly managed	105 (34.9)	3 (1.0)	108 (35.9)
Total	253 (84.0)	48 (16.0)	301 (100)

4.3. DAIRY PERFORMANCE ON THE BASIS OF THE GENDER OF THE HOUSEHOLD HEADS AND DAIRY ENTERPRISE MANAGERS

One of the objectives of this study was to make a comparison between male and female smallholder dairy farmers. Both dairy production and dairy productivity were used as common denominators in this case. Dairy production was defined as the total milk output (in

litres) from the farm per day, while dairy productivity referred to the average milk output (in litres) per lactating cow per day from a farm. Men farmers had both higher dairy production and dairy productivity than women farmers (female-headed households, *see* Table 4.). The mean dairy production difference between male and female-headed households was significant at the 5 per cent level, while mean dairy productivity difference was significant at 10 per cent.

Metz *et al* (1995) has propositions, which attempt to explain this scenario. First, men have had more contact with extension services in the past. Therefore, they had opportunity to accumulate more knowledge and develop better skills with respect to intensive dairy farming than women, i.e. the past gender imbalance with respect to extension services has put male farmers in a more advantaged position than women farmers. Secondly, the same study reckons that men are thought to be more interested in dairy enterprise as a source of cash income and, therefore, they try to achieve high levels of milk yield. Unlike men, women's interest is thought to be more towards the milk for home consumption and, therefore they may not necessarily try to achieve high milk yields as a commercial priority beyond family needs.

Table 5: Mean dairy production and dairy productivity for male and female-headed households in Embu district.

Gender of household head	Dairy production (litres/day/farm)	Dairy productivity (litres/cow/day)
Male (n=253)	7.70	5.90
Female (n=48)	5.70	5.00
Mean	7.40	5.70
Significance (p-value)	0.012	0.077

Another probable explanation for the observed pattern in dairy performance could be the differences in resource endowment levels of the households, e.g. access to off-farm income or income from milk sales which could be invested in inputs to raise output and productivity and other yield increasing inputs. As Saito (1990) found out in studies done in Kenya, Nigeria and Burkina Faso, male-headed households were on average more endowed with resources than female-headed households. In this study, it was found that male-headed households had on average, more monthly income, capital used in dairy, access to dairy feeds, improved fodder plants and more years of education than female household heads. Female household heads were endowed on average, with more land (5.15 acres as opposed to the male's 4.75 acres) than their male counterparts. Mwambazi (1994) obtained a similar result in Monze District of Zambia. She found that female-headed households were endowed with more land on average than male-headed households. The female household heads in her study were mainly widows. Although they owned more total land, this did not necessarily mean that they had more total land utilized for dairying than male-headed households. There were other crucial land-use activities (in the farmers' opinion) than dairying. For instance, the farmers ranked tea and coffee ahead of dairy as the most important land-use activities in the region. In addition, most of the female-headed households (54 per cent of them) were found in the more arid areas (Runyenjes Division) where they tended to practice extensive grazing to supplement zero grazing. Extensive practices of dairy husbandry are associated with low dairy productivity. Such lands are less costly and therefore, the resource-constrained female farmers can afford them.

Male-managed dairy enterprises registered the highest dairy production and dairy productivity, followed by jointly managed and lastly by the female-managed dairy

enterprises. In fact, female-managed dairy enterprises realized less than the overall sample means of dairy production and dairy productivity. The situation was understood when it was seen that about 100 per cent of the male-managed and an approximately similar percentage of the jointly managed dairy enterprises were from the male-headed households, who on average were endowed with more resources than the female-headed households. The results showed significant mean differences in dairy productivity between the three types of dairy enterprises, as opposed to dairy production (Table 6). The analysis indicated that the significant (p=0.084) mean dairy productivity differences were between the male-managed and female-managed dairy enterprises only.

Table 6. Mean dairy production and productivity for male, female and jointly managed dairy enterprises.

	Mean Dairy production (litres/day/farm)	Mean Dairy productivity (litres/cow/day)
Male managed (n=52)	8.90	6.50
Female managed (n=141)	7.00	5.20
Joint managed (n=108)	7.10	6.00
Entire sample	7.40	5.70
Significance (p-value)	0.382	0.084

The male-managed dairy enterprises were found to have access to a significantly higher level of commercial dairy feeds than the other dairy enterprises. They were endowed with significantly higher capital levels than the others. Without considering the household from which they fell under, female-managed dairy enterprises (*de facto* and *de jure* female-managed dairy enterprises combined) were endowed with very little of the two factors of production.

managed dairy enterprises had the highest mean number of improved fodder plants followed by the jointly managed and lastly the female managed dairy enterprises despite the absence of significant differences. The differences may be due to the skewed access to extension services and also KARI's on-farm trials, which introduced the technology to the areas, in favour of the male farmers as opposed to the female farmers. As Saito (1990) indicates, this may be due to direct bias by the frontline extension staff where they prefer to talk to men than to women farmers, or it may be due to wrong choice of the extension method which favour men. The effect is that, the dairy productivity by male farmers would differ from that of the female farmers because of this state of affairs.

A comparison of the dairy performance between adopters and non-adopters showed that those farmers who had adopted the improved fodder plants technology realized significantly (both at 5% level of significance) higher dairy production and higher dairy productivity than those who had not (Figures 5 (a) and 5 (b)).

The information in Table 6 indicates that the least performers in dairy farming were the female-managed dairy enterprises from the female-headed households.

Table 7: Dairy in male- and female-headed households.

	Gender of household head			
	Male head (n=253)		Female head (n=48)	
	Productivity	Production	Productivity	Production
Male (n=52)	6.30 (n=49)	8.90 (n=49)	8.50 (n=3)	8.50 (n=3)
Female (n=141)	5.50 (n=99)	7.90 (n=99)	4.60 (n=42)	5.20 (n=42)
Joint (n=108)	6.00 (n=105)	7.10 (n=105)	7.60 (n=3)	9.60 (n=3)

The female-managed dairy enterprises from male-headed households (*de facto* female-managed dairy enterprises) realized higher dairy performance (productivity and production) than those female-managed dairy enterprises from female-headed households (*de jure* female-managed dairy enterprises). This result confirms expectations based on other gender-differentiated studies in agricultural production (Inoti *et al*, 1994). Such dairy enterprises (*de jure*) are the least endowed with dairy farming resources compared to the others (Appendix 2).

4.4 EFFECT OF *CALLIANDRA CALOTHYRSUS* ON DAIRY PERFORMANCE

Another objective was to compare the dairy performance between the adopters and non-adopters of improved fodder plants technology. Calliandra being the major fodder plant in the region was used for the purpose. Male-headed households had more *Calliandra calothyrsus* plants, on average (mean of 31 plants), than the female-headed households (mean of 1 plant). The mean differences were also found to be significant ($p = 0.013$). Male

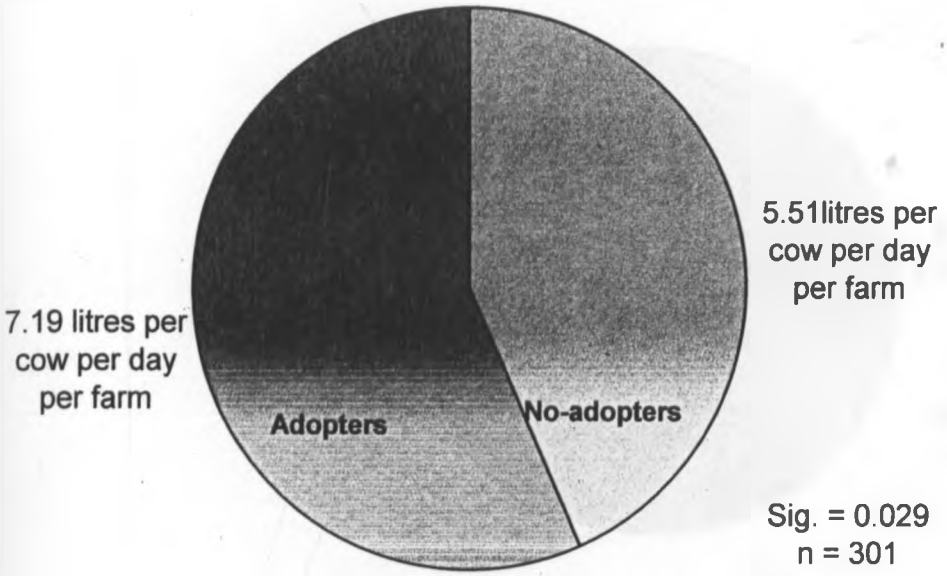
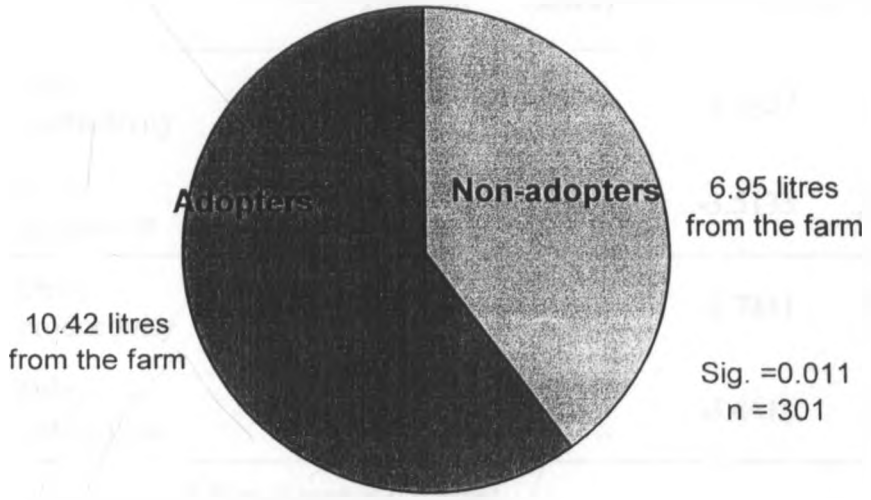


Fig.5 (a) A comparison of the mean dairy productivity between farmers with and those without Calliandra calothyrsus technology

Figure 5 (b): Mean dairy Production difference between adopters and non-adopters



The information in appendix 3 and table 7 indicates that there were significant mean dairy production (p=0.035) and dairy productivity (p=0.019) differences between those male-headed households with, and those without *Calliandra calothyrsus*. For the female-headed households, appreciable differences (p=0.099) were observed only for the mean dairy production between those households with and those without *Calliandra calothyrsus*. No appreciable mean differences were observed for dairy productivity between the adopters and non-adopters of the technology within the female-headed households.

Table 8: Independent Sample t-test for Equality of Means amongst male and female-headed households with and without *Calliandra calothyrsus.*

Gender of household head		t-statistic	Degrees of freedom	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Female	Dairy productivity	-.938	46	.353	-1.2427	1.3252
	Dairy production	-1.684*	46	.099	-3.5135	2.0869
Male	Dairy productivity	-2.363**	250	.019	-1.7431	.7376
	Dairy production	-2.120**	250	.035	-3.4416	1.6234

** Significant at 0.05 level, * Significant at 0.1 level

The fodder plants technology adopters within the male-managed and jointly managed dairy enterprises realized significantly higher dairy productivity than the non-adopters. No significant differences in dairy productivity were observed for the female-managed dairy enterprises between the adopters and the non-adopters. The low improved fodder technology adoption levels amongst the female-managed dairy enterprises may explain this. Apart from the jointly managed dairy enterprises, no significant mean dairy production differences were observed for the other dairy enterprises between the adopters and non-adopters of the fodder plants technology.

Considering both *de facto* and *de jure* female-managed dairy enterprises, it was found that the former showed significant difference in both dairy production and dairy productivity between the adopters and the non-adopters. Since the *de facto* female-managed dairy enterprises come from households headed by men, it follows that they are endowed with

more dairy farming resources than the *de jure* female-managed dairy enterprises. Therefore, they had the complementary means to access the technology more readily.

4.5. EFFECT OF ZERO-GRAZING DAIRY TECHNOLOGY ON DAIRY PERFORMANCE

Ninety five per cent of the farmers were practicing some form of zero grazing. Only few farmers practicing open grazing were found mainly in the drier southern region of Runyenjes Division. Of these, more than half were female-headed households. Analysis indicated that farmers who had adopted the zero grazing technology realized more dairy production and productivity than those open-grazing their livestock.

4.6. REGRESSION RESULTS

To evaluate the effect of socio-economic factors on dairy production amongst male and female smallholder dairy farmers, a number of regressions were executed. A general Cobb-Douglas regression was executed first for all the farmers (Table 9), then for the male-headed and female-headed households. Appendices 7 and 8 contain the regression results for the male-managed, female-managed and the jointly managed dairy enterprises.

Table 9: Dairy production and dairy productivity estimates of Cobb-Douglas production functions for Embu district, Kenya.

Explanatory variables	Dairy production	Dairy productivity
Constant	-0.723 (-0.677)	0.237 (0.192)
1.Land		
Total land area (acres)	-0.084* (-1.809)	-0.072 (-1.319)
Land area under Napier (m^2)	0.026 (0.607)	0.044 (0.905)
2.Labour		
Family labor	-0.050 (-1.223)	-0.069 (-1.424)
Male hired regular labor (No. of adult persons)	0.037 (0.947)	0.000 (-0.009)
Female hired regular labor (No. of adult persons)	0.006 (0.131)	0.043 (0.994)
3. Capital		
Market value of tools and equipment for dairy (Kshs)	0.108** (2.346)	0.114** (2.114)
Gross monthly income (Kshs)	0.144*** (3.183)	0.172*** (3.262)
Total amount of money spent on commercial feeds per month Kshs)	0.074 (1.606)	0.077 (1.438)
Estimated quantity of cut fodder per livestock unit (kg)	-0.012 (-0.260)	-0.017 (-0.323)
4. Household characteristics		
Gender of household head (1=male, 0=female)	0.069* (1.664)	0.082* (1.650)
Years of livestock farming by household head	0.047 (1.001)	0.065 (1.093)
Years of formal education by household head	-0.032 (-0.680)	-0.031 (-0.559)
Years of formal education by spouse to household head	0.089** (1.988)	0.105** (2.003)
Controller of income from milk sales (1=farm manager, 0=otherwise)	0.096** (2.443)	0.124*** (2.679)
Occupation alternative to farming by the household head (1=yes)	-0.106** (-2.335)	-0.126** (-2.375)
Alternative occupation by spouse to household head (1=yes)	0.074 (1.616)	0.081 (1.513)
5. Market and institutional factors		
Milk price (Kshs/700ml bottle)	-0.025(-0.608)	-0.050 (-1.068)
Commercialization index	0.165*** (3.431)	0.193*** (3.424)
Distance to milk market (km)	-0.016 (-0.398)	-0.045 (-0.955)
Access to credit by household (1=yes, 0=no)	0.056 (1.352)~	0.059 (1.208)
Access to extension visits (1=visited, 0=not visited)	0.053 (1.220)	0.056 (1.113)
6. Others		
Livestock herd size (livestock units)	0.096* (1.794)	-0.072 (-1.319)~
No. of lactating cows	0.372*** (6.831)	0.036 (0.565)
Lactation stage of the cow (months)	-0.369*** (-8.705)	-0.432*** (-8.733)
Number of improved fodder trees on the farm	0.015 (0.359)	0.025 (0.504)
Whether zero-grazing unit is present on the farm (1=yes, 0=no)	0.054 (1.358)	0.062(1.336)
Division (1=Manyatta, 0=Runyenjes)	0.074 (1.622)	0.073 (1.367)
R^2	0.610	0.470
Adjusted R^2	0.571	0.416
Standard error of estimate	0.5405	0.5460
F statistic	15.781***	8.620***
P value	0.000	0.000
n	301	301

*Significant at 10% level, **Significant at 5% level, *** Significant at 1% level, t-statistics in parentheses

4.6.1. DISCUSSION OF REGRESSION RESULTS

The F value from the general regression (Table 9) showed that the independent variables were jointly significant at one per cent level in explaining dairy production and dairy productivity amongst the Embu smallholder dairy farmers. The R^2 values of 0.610 and 0.470 for dairy production and productivity respectively, indicated that, degrees of freedom not withstanding, the regression plane explained 61.0 per cent of the total variation of the values of dairy production and 47.0 per cent of the total variation of dairy productivity. Correcting for degrees of freedom, the coefficients of determination of 0.571 and 0.416 indicated that the regression plane explained 57.1 per cent and 41.6 per cent of the total variation of the dairy production and productivity, respectively. Therefore, about 43 per cent of variation in dairy production and 58 per cent of variation in dairy productivity were unexplained.

Table 10: Regression Results for Dairy Production and Dairy Productivity among Male-headed households

Explanatory variables	Dairy production	Dairy productivity
Constant	-1.251 (-1.041)	0.604 (0.498)
1. Land		
Total land area (acres)	-0.046 (-0.887)	-0.030 (-0.492)
Land area under Napier (m^2)	0.038 (0.843)	0.062 (1.161)
2. Labour		
Family labor	-0.068 (-1.449)	-0.098 (-1.851)
Male hired regular labor (No. of adult persons)	0.007 (0.161)	0.006 (0.105)
Female hired regular labor (No. of adult persons)	0.056 (1.321)	0.067 (1.346)
3. Capital		
Market value of tools and equipment for dairy (Kshs)	0.089* (1.798)	0.090 (1.560)
Gross monthly income (Kshs)	0.113** (2.355)	0.133** (2.365)
Total amount of money spent on commercial feeds per month (Kshs)	0.078 (1.544)	0.087 (1.471)
Estimated quantity of cut fodder per livestock unit (kg)	0.007 (0.140)	-0.004 (-0.064)
4. Household characteristics		
Gender of household manager (1 = male, 0 = female)	0.052 (1.200)	0.050 (0.994)
Years of livestock farming by household head	0.044 (1.816)	0.041 (0.652)
Years of formal education by household head	0.014 (0.280)	0.035 (0.600)
Years of formal education by spouse to household head	0.099** (2.035)	0.120** (2.105)
Controller of income from milk sales (1=farm manager, 0=otherwise)	0.118*** (2.802)	0.146*** (2.956)
Occupation alternative to farming by the household head (1=yes, 0=no)	-0.137*** (-2.938)	-0.161*** (-2.938)
Occupation alternative to farming by spouse to the head of the household (1=yes, 0=no)	0.070 (1.389)	0.072 (1.226)
5. Market and institutional factors		
Milk price (Kshs/700 ml bottle)	-0.006(-0.134)	-0.035 (-0.673)
Commercialization index	0.197*** (3.739)	0.225*** (3.656)
Distance to milk market (km)	-0.028 (-0.650)	-0.061 (-1.214)
Access to credit by household (1 = yes, 0 = no)	0.069 (1.542)~	0.070 (1.343)
Frequency of extension visits (1 = visited, 0 = not visited)	0.600 (1.400)	0.074 (1.350)
6. Others		
Livestock herd size (livestock units)	-0.046 (-0.887)	-0.030 (-0.492)
No. of lactating cows	0.331*** (5.510)	-0.014 (-0.196)
Lactation stage of the cow (months)	-0.338*** (-7.310)	-0.399*** (-7.375)
Number of improved fodder trees on the farm	0.003 (0.070)	0.007 (0.129)
Whether zero-grazing unit is present on the farm (1 = yes, 0 = no)	0.051 (1.181)	0.062(1.161)
Division (1 = Manyatta, 0 = Runyenjes)	0.054 (1.111)	0.047 (0.825)
R^2	0.636	0.500
Adjusted R^2	0.592	0.440
Standard error of estimate	0.5364	0.5416
F statistic	14.488***	8. 296***
P value	0.000	0.000

Significant at 10% level, ** Significant at 5% level,

*** Significant at 1% level, t-statistics in parentheses

4.6.1.1. Land (Farm Size)

There was a strong negative relationship between total farm size and dairy production on one hand, and an insignificant relationship between farm size owned and dairy productivity on the other. Farm size is usually known to have a positive relationship with crop yields (Jamison *et al*, 1982, Udry *et al*, 1995). The same relationship was hypothesized in this case of dairy. The negative relationship implied that, given extra land, the farmers in Embu District would put more of it under alternative uses to dairy farming activities. This was understandable given the lucrativeness of high value (export crops) tea and coffee in the study area. From these results (Table 9), the elasticity of dairy production with respect to total land ownership by a household in Embu was -0.084 suggesting that a 10 per cent increase in farm size would lead to a 0.84 per cent fall in total milk output per household. Presumably, the farmers would shift their attention mainly to maximize profits from coffee and tea production now that there would be more land to achieve that. Alternatively, the larger the farm sizes, the more likely the farmers would practice extensive grazing resulting in lower productivity. Similar results were observed for the female-headed households when considering dairy production (Table 11). This implies that the female farmers, instead of increasing their livestock herd size with increases in land size, they would divest from dairy and invest in other activities, thereby reducing the amount of milk realized from their farms daily.

There was no significant influence of the size of land under Napier with dairy production and dairy productivity. Considering napier as the main cut fodder for livestock under zero grazing, the stocking rates for most farmers in Embu District were way above the carrying capacities of their farms. As such, they relied on purchased napier for their livestock feeding in addition to the use of other naturally growing green matter. A negative significant influence of land size under napier grass on dairy productivity was observed for the female-headed households. The lesser the amount of napier owned by female-headed households, the more supplementation (either from bought fodder or commercial dairy meals) would be given to the cows.

Table 11: Regression Results for Dairy Production and Dairy Productivity among Female headed households

Explanatory variables	Dairy production	Dairy productivity
Constant	-2.137 (-0.730)	-2.292 (0.781)
1. Land		
Total land area (acres)	-0.297** (-2.172)	-0.3266 (-2.127)
Land area under Napier (m^2)	-0.274 (-1.957)	-0.311* (-1.984)
2. Labour		
Family labor	0.000 (-0.003)	0.003 (0.016)
Male hired regular labor (No. of adult persons)	-	-
Female hired regular labor (No. of adult persons)	-	-
3. Capital		
Market value of tools and equipment for dairy (Kshs)	0.140 (0.979)	0.162 (1.012)
Gross monthly income (Kshs)	0.424** (2.702)	0.473** (2.688)
Total amount of money spent on commercial feeds per month (Kshs)	0.150 (1.104)~	0.169 (1.101)
Estimated quantity of cut fodder per livestock unit (kg)	-0.040 (-0.291)	-0.043 (-0.280)
4. Household characteristics		
Gender of household manager (1 = male, 0 = female)	-0.021 (-0.147)	-0.024 (-0.150)
Years of livestock farming by household head	-0.012 (-0.084)	-0.018 (-0.112)
Years of formal education by household head	-0.161 (-0.884)	-0.184 (-0.903)
Years of formal education by spouse to household head	0.164 (1.110)	0.185 (1.120)
Controller of income from milk sales (1=farm manager, 0=otherwise)	-0.020 (-0.137)	0.018 (0.112)
Occupation alternative to farming by the household head (1 = yes, 0=no)	0.243 (1.464)~	0.275 (1.482)
Occupation alternative to farming by spouse to the head of the household (1 = yes, 0 = no)	-0.125 (-0.737)	-0.140 (-0.736)
5. Market and institutional factors		
Milk price (Kshs/700 ml bottle)	0.018 (0.131)	0.029 (0.184)
Commercialization index	0.058 (0.351)	0.066 (0.357)
Distance to milk market (km)	0.130 (0.714)	0.141 (0.692)
Access to credit by household (1 = yes, 0 = no)	-0.237 (-1.605)~	0.268 (1.616)
Frequency of extension visits (1 = visited, 0 = not visited)	0.020 (0.160)~	0.021 (0.152)
6. Others		
Livestock herd size (livestock units)	-0.137 (-0.798)	-0.326** (-2.127)
No. of lactating cows	0.497** (2.334)	0.192 (0.804)
Lactation stage of the cow (months)	-0.337** (-2.519)	-0.377** (-2.523)
Number of improved fodder trees on the farm	0.137 (1.026)	0.152 (1.015)
Whether zero-grazing unit is present on the farm (1 = yes, 0 = no)	-0.001 (-0.010)	0.003 (0.016)
Division (1 = Manyatta, 0 = Runyenjes)	0.274 (1.686)	0.305 (1.676)~
R^2	0.763	0.700
Adjusted R^2	0.505	0.380
Standard error of estimate	0.5241	0.5255
F statistic	2.958***	2. 175**
P value	0.005	0.033

* Significant at 10% level, ** Significant at 5% level

*** Significant at 1% level, t-statistics in parentheses

4.6.1.2. Labour

Labour as a factor of production in dairy was differentiated into family labour, male hired labor and female hired labor. Whereas, hired labor indicated an insignificant positive relationship with both dairy production and dairy productivity, family labor showed a negative relationship. The problem might have been due to the difficulty associated with delineating the portion of labour services within a household that was for dairy and that which was for other activities. This gave an impression that the households had an oversupply of family labour in dairy farming, a conclusion that would be inconsistent with similar studies (Kilungo, 1999). However, overwhelming evidence from the Participatory Research Appraisal (PRA) study showed that female family labor was the most important one in dairy.

4.6.1.3. Capital

Capital in the form of value of tools and equipment used in dairy, and the gross monthly income showed a positive linkage to both dairy production and dairy productivity. An insignificant relationship was observed between the total amount of money spent on dairy feeds per month and both dairy production and dairy productivity. The lack of significance could be attributed to the fact that part of the effects of this variable might have been captured by such other factors like amount of income per month - assuming that part of the monthly income was utilized for purchase of dairy feeds. The amount of cut fodder fed to the cows had a negative insignificant relationship with both dairy production and productivity. There was a universal use of banana tree stems as animal fodder in the study area, without regard for its low nutritive value. Whereas most farmers used the banana stems

because there was lack of money to buy feeds, or there was no alternative/adequate fodder, some were ignorant of the low nutritive status of the banana stems. The more of it that was fed to the cows, the lesser of the other nutritious feeds was given to the cows, hence the negative relationship. Kilungo (199) also found a negative (though significant) relationship between amount of fodder given to the dairy animals and milk production. He attributes the discrepancy to the low milk yield limit beyond which forages cannot stimulate positive marginal yields of milk with further feeding. The forages are bulky and their nutritional capacity per unit weight lower in comparison to the concentrates.

4.6.1.4. Household Characteristics

The results contained in Table 9 show that the gender of the household head was an important factor in explaining both dairy production and productivity. The coefficients were significant with the expected positive signs. This showed that male-headed households, on average, were better performers in both dairy production and dairy productivity than female-headed households. This deviates from some studies done elsewhere on crops, whose regression results indicated an insignificant coefficient associated with gender of the household head (Moock, 1976; Jamison and Lau, 1982; Bindlish and Evenson, 1993; Mwambazi, 1994; Saito *et al,* 1994 and Quisumbing, 1995). The difference from these other studies may lie in the fact that the current study is concerned with dairy while the others dealt with crops.

The coefficients for education of the household head were small, had the wrong sign and were insignificant. Education for the household head who, in most cases, was a male, was not utilized in dairy as he was either absent from the farm for long periods or his effort was

concentrated more in the two major cash crops, tea and coffee. It was also possible that the content of formal education had little bearing on farming skills as a whole. In fact, as Saito (1994) puts it, the process of formal education in sub-Saharan Africa orients students away from agriculture and the returns to education in off-farm work may be higher. An interesting observation was made when education of the spouse to the household head was introduced in the model. The variable had a significant positive coefficient for both dairy production and dairy productivity. Though most households were male-headed, women (spouses) rather than men managed most of the dairy enterprises. It follows, therefore, that women's education was actually put to use in dairy farming (as opposed to that of the men) i.e., their education gave them the ability to understand and appreciate new things in dairy farming over time as they stayed on the farm. The cultural set-up conditioned most women to stay and work on the farms, thereby utilizing their education in farming. Similar results were observed in the regressions for the male-headed households (Table 10).

The years of livestock farming by the household head had a positive but insignificant coefficient. The variable was highly correlated with the age of the household head and the spouse, which were omitted in the analysis. The result might be a pointer to the reluctance of many farmers to change from the traditional (known) practices to the modern practices in dairying. The change was evident but the rate was very low (hence the positive but insignificant production elasticity). In addition, the changing structure in dairy farming occasioned by changes in the socio-economic environment calls, possibly for experience in modern dairy farming rather than just 'experience in dairy farming' *per se*. Irrespective of how long a farmer has been practicing his/her trade, there is need to adopt new innovations like proper zero-grazing, improved nutrition methods and ensure proper health of the

livestock for improved dairy performance.

The controller of the income from milk sales in a household was an important variable affecting the performance of dairy. The coefficient in both dairy production and dairy productivity was significant with the expected sign. This was in agreement with a World Bank study (1989). The dairy production elasticity and that of dairy productivity with respect to the controller of income from milk sales were 0.096 and 0.124 respectively (see Table 9). This is also true for the regression covering the male-headed households. The significance of the variable, being a dummy, meant that the total amount of dairy production and dairy productivity for dairy farms where the farm manager controlled milk income were higher than those farms where it was not the case. The results were thus consistent with Mullins *et al's* (1996) findings in western Kenya where lack of control of dairy income by the dairy enterprise manager had a negative influence on milk output even in the face of higher milk prices.

Availability of off-farm employment for the household head significantly affected dairy production and productivity negatively. However, the coefficient associated with the household head spouse's off-farm employment had no linkage with both dairy production and dairy productivity. The off-farm employment for the household head kept him away from the farm implying that major decisions affecting the dairy enterprise were deferred until his or her return. Though farmers with off-farm employment had more monthly income to hire a livestock attendant, their absence from the farm had a stronger dairy performance-depressing effect than the higher income. Dairy productivity, being more sensitive and requiring intense and sustained input coordination appeared more affected by this absence of

the household head than dairy production.

4.6.1.5. Market and Institutional factors

The most important factor in this category was the commercialization index. The commercialization index was an indication of the availability of market for the raw milk produced by the dairy farmers. The dairy production elasticity with respect to the commercialization index was 0.165, implying that if the milk outlet could expand by 10 per cent, it would cause a 1.65 per cent increase in milk yield per farm per day *ceteris paribus*. Similarly (see Table 9), the dairy productivity elasticity with respect to the commercialization index was 0.193 implying that if the milk outlet could expand by 10 per cent each cow's daily milk yield would shoot up by around 1.93 per cent, *ceteris paribus*. A scenario similar to the above was observed for the male-headed households' regression results (see Table 11). The results for the female-headed households showed an insignificant relationship reinforcing the theory that women are inclined more towards farm output for home rather than market consumption as their primary concern (Metz *et al*, 1995).

The production elasticities for extension with respect to dairy production and productivity were insignificant. The results contradicted some other studies, which consistently indicated that extension as the bridge between research and farmers was a very important input for improved performance in agriculture. The results of this study imply that the values of dairy production and dairy productivity for farmers who had contact with extension agents were not significantly higher than for those who did not. This may be attributed to the low number of households (30) that had received extension advice on livestock production in general and dairy in particular, 12 months prior to the survey. Though most farmers attended

coffee society meetings, little was talked about livestock production in general and dairy farming in particular. Throughout the whole survey, very few farmers confessed to having received extension services within the last 12 months. Many could not remember the last time they ever saw a livestock extension agent.

Access to credit did not significantly influence dairy production and dairy productivity possibly due to the ineffectiveness of the low amounts of credit advanced to the farmers by their co-operative societies. A number of the farmers reluctant in taking loans because they feared enterprise failure or lack of market for their produce, which would lead to the compulsory acquisition of their property by the lending institutions. Farmers sought credit in very small amounts. None of the farmers sought credit from formal banks, despite available tangible collateral in the form of land and in some cases, performing businesses. The problem of lack of dairy operating capital was aggravated by the much lower amounts of the credit that was spared for dairy activities, given the many competing demands for it within a household.

The distance to the milk market did not significantly affect dairy production and dairy productivity. The milk market points were local shopping centers, hotels, and the Kenya Co-operative Creameries (KCC) milk processing plant and Embu town itself. Save for the KCC plant, taking milk to the other centers was no guarantee that it would be accepted and paid for. Often farmers returned home from the various market outlets with some unsold milk. The KCC plant offered no solution either, because farmers were supplying milk there as the last resort, since payments for deliveries could take as long as a year or more. In the meantime, the lactating cows needed feed and veterinary care, which were a cost to be

serviced regularly. Hence preference was given to the informal, even though unreliable, market.

The price of milk did not seem to be significant in influencing dairy production and dairy productivity. This was in direct contrast to Ruigu's (1978) work, where he recorded that milk price (besides input prices) was critical in determining milk production levels. A correlation analysis indicated lack of correlation between amount of milk produced and price. The results of the present study could be attributed to the low variation in milk price over the study area. Milk price ranged from about Kshs. 16.00 to Kshs. 19.00 per liter over the whole region, with no variation over some large areas. Also, the apparent 'excess' milk supply over demand in the study area may have masked the effects of the price. About 40 per cent of the milk produced daily could find market. Since home consumption accounted for about 30 per cent, it means that another 30 per cent of the milk could not find market, at the existing price.

4.6.1.6. Other Factors

The herd size and number of lactating cows on a farm positively affected dairy production. It was apparent that a large herd size indirectly affected dairy production by signaling to the farmers the need to invest more heavily in terms of feeds and veterinary services given the "larger scale" of operation. In addition, the more the number of lactating cows the higher the milk output from the farm on a daily basis, *ceteris paribus*. There was no significant linkage between dairy productivity and livestock herd size for the male-headed households. Regression results for the female-headed households showed a significant negative relationship between livestock herd size and dairy productivity. The limited resource base

for this category of farmers and the keeping of more livestock numbers implied a much lower input allocation on a per capita basis for the animals. This multiplied into lower dairy productivity with more animals.

From the principles of animal production, the longer the animal has stayed after parturition, the less the milk it produces. Therefore, it was not surprising that the relationship of this variable with both dairy production and dairy productivity was negative and significant.

The number of improved fodder trees on the farm had no significant influence on dairy production and dairy productivity. The low level of these plants on the farms was a more plausible rationale for this situation. Most farmers either did not have the Calliandra fodder plants on their farms or they had never heard of them. Some of those who had them did not know the feeding levels required for their cows. It was apparent that, ten years along the line since introduction the technology had not spread sufficiently from the trial farmers to the others.

The descriptive analysis showed that farms with zero-grazing units realized higher dairy production and dairy productivity than those without. However, from the regression analysis, the coefficients associated with this variable were not significant. This may be attributed to the very few farms (11) according to this survey that did not have a zero-grazing unit.

There was no significant dairy performance variation on the basis of administrative divisions, implying that dairy production and dairy productivity in Manyatta were not significantly higher than those in Runyenjes. Though Runyenjes division had a semi-arid

southern region, its effect on dairy performance overall was not significant. This could be attributed to the low number of farmers per unit area in the region.

4.7. SIMULATION OF DAIRY PRODUCTION AND DAIRY PRODUCTIVITY BETWEEN MALE AND FEMALE FARMERS

The foregoing results showed that gender differences did exist in the use of the factors of production for dairy production and dairy productivity. By use of the mean values of dairy production and dairy productivity, men realized higher dairy production and dairy productivity than women. Male-headed households had a dairy production value of 7.70 while women-headed households registered 5.70. In terms of dairy productivity, male-headed households showed an average value of 5.90 while female-headed households show 5.00. This was confirmed by the shift in the parameter in the Cobb-Douglas production function (Table 9). However, the male-headed households had different dairy resource endowments from female-headed households (Appendix 2). The question to answer was: if women were given the same quantities and qualities of factors as men, would they have been as productive as the men?

The coefficients from the production function estimates for female-headed households and the mean values of the independent variables for the male-headed households were used to predict the values of dairy production and dairy productivity for female-headed households. These were compared with the predicted values of dairy production and dairy productivity using the mean values of the independent variables for female-headed households. The results showed that, with existing endowments, men's mean gross dairy production was 26.0 per cent higher than for the women while the gross dairy productivity was 15.2 per cent

higher. This simulation suggested that if women had the same access to resources as men, the value of their dairy production would have increased by 15.3 per cent and that for dairy productivity would have increased by 16.4 per cent. The former would not close the dairy production gap between male and female farmers, but the latter would more than fully close the gap between male and female farmers' productivity in dairy. Because dairy productivity within female-headed households would have risen by more than the difference between the mean values in the two types of household, the results suggest that women could offer a better opportunity for efforts to improve dairy productivity than men farmers. However, the male farmers would still be better in dairy production than the female farmers.

These simulation results, however, should be treated with caution since they do not indicate how the levels of inputs for women could be raised. For instance, should the higher levels of inputs just be forced on the female farmers? To a great extent, differences in input use may be driven by differences in education (since more educated farmers are more likely to use modern inputs). Similarly, they may be driven by years of livestock farming by a household since the more experienced a farmer is the higher the chances that he or she will use more optimum levels of inputs. These simulations may also inaccurately depict the gains if a change did occur in input use, since the Cobb-Douglas production function technology assumes constant elasticities, and presupposes that changing the levels of one input does not change the elasticities of other inputs.

An alternative approach would be to perform an Oaxaca decomposition of the yield differential between male and female farmers (Oaxaca, 1973 as reported by Quisimbing, 1995). Although this approach was used to decompose the wage gap, it could also be applied

in this case as follows:

$$1_m - 1_f = ß_m(8_m - 8_f) + (ß_m - ß_f)8_f$$

Where:

1_m and 1_f represent mean dairy production/productivity of male headed and female headed households respectively

$ß_m$ and $ß_f$ are estimated output coefficients of male and female farmers

8_m and 8_f are mean levels of endowments and inputs of male-headed and female-headed households.

That is, the overall average male-female yield gap could be decomposed into the portion due to differences in input endowments ($8_m - 8_f$), evaluated using male-headed household coefficients. The other portion is attributable to the differences in the returns, or output elasticities ($ß_m - ß_f$), that male and female farmers get for the same endowment or input application.

However, this type of analysis was not attempted in this study. Future studies should look into the feasibility of using this approach.

4.8 DATA PROBLEMS

During the data collection process, some unavoidable inconveniences were encountered. The time of data collection coincided with the season of peak tea harvesting and as such it

was hard to convince a farmer to take off two hours to participate in the interview. This delayed data collection and processing. Sometimes, either the dairy enterprise manager or the household head was absent from the farm implying that he/she had to be followed either to the market or to the working place to give the interview. This was an activity that consumed a lot of time.

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1. SUMMARY AND CONCLUSIONS

This study set out to broadly investigate the performance of smallholder dairy farming in Embu District, given the efforts being made for the farmers to adopt improved fodder plants as substitutes or supplements to commercial dairy meals. The study incorporated the gender aspect to address the contributions to dairy farming by both male and female farmers. A participatory Rural Appraisal (PRA) was initially done to put the dairy farming activities in the two sample Divisions (Manyatta and Runyenjes) in perspective. The study comprised mainly a household survey that employed the use of a structured questionnaire and informal discussions with relevant groups of stakeholders. The whole sample size was three hundred and one farmers. The total sample was divided into Male-headed households (n=253) and female-headed households (n=48). The data on pertinent issues of dairy performance was subjected to descriptive and quantitative analyses.

The first objective was to assess the dairy performance differences between smallholder male and female farmers. The second objective was to asses the dairy performance differences between farms where improved fodder plants technology (and other technologies like zero grazing) had been adopted and those farms where the technology had not been adopted. The third objective was to evaluate the effects of social, economic and cultural factors on dairy performance among male and female smallholder farmers. Dairy performance was represented by dairy productivity and dairy production. Dairy production was taken as the total amount of milk produced from the farm in a day, while dairy

productivity represented the amount of milk yield per cow per day from a farm. The dairy performance differences were first assessed at the household level, then at the dairy enterprise level.

The PRA results indicated that women mainly managed the dairy enterprises within Embu district. Women also provided most of the daily labor used in dairy farming within households. However, the husband and the wife jointly made major decisions pertaining to the control over resources and output within households. In case of a disagreement on any of the above, the household head could make unilateral decisions.

5.1.1 DAIRY PERFORMANCE: MALE VS FEMALE FARMERS

Male-headed households were found to register significantly ($p=0.012$) higher mean dairy production than female-headed households. Simulation results showed that, women heads would still realize lesser dairy production compared to the men heads even when given the same factors of production as the men. This left the differences in dairy production between men and women heads to be due to variation in acquired managerial ability.

Without considering nature of the household, male-managed dairy enterprises realized significantly higher dairy production than both jointly managed and female-managed dairy enterprises. Female-managed dairy enterprises showed the least dairy production. The difference in dairy production between the male-managed and jointly managed dairy enterprises was not significant.

De jure female-managed dairy enterprises (from female-headed households) showed the

lowest dairy production. In fact, their dairy production was significantly (p=0.048) less than that of the *de facto* female-managed dairy enterprises (from male-headed households). This confirmed expectations based on other gender-differentiated studies of agricultural production (Maarse, 1998). The other dairy enterprises (male or jointly managed) showed no dairy production differences considering which household type they came from.

In terms of dairy productivity, it was found that male-headed households showed significantly (p=0.077) higher dairy productivity than female-headed households did. However, simulation analysis showed that, given the same resources as the men, women farmers would realize higher dairy productivity than the men farmers would. The results were a deviation from those obtained when a simulation analysis was run for dairy production. This may be taken to mean that women farmers are better suited dealing with fewer dairy animals as opposed to male farmers. Just like for dairy production, the *de jure* female-managed dairy enterprises showed the least dairy productivity. Male-managed dairy enterprises showed significantly higher mean dairy productivity difference from that of female-managed dairy enterprise. Jointly managed dairy enterprises did not show significant dairy productivity difference from that of either male or female-managed enterprises..

5.1.2. PERFORMANCE ON THE BASIS OF TECHNOLOGY ADOPTION

Irrespective of gender, improved fodder plants technology adopters realized significantly higher dairy production (p=0.011), than the non-adopters. Considered separately, male-headed and female-headed households with *Calliandra calothyrsus* realized significantly higher dairy production (p=0.035, and 0.099 respectively) than the non-adopters.

No appreciable dairy production differences were observed between the adopters and non-adopters of the zero-grazing dairy technology, when the whole sample size was considered. The negligible proportion of households without the zero grazing dairy technology could account for the lack of significant mean dairy production differences between the adopters and the non adopters of this technology.

In general, women were found managing forty seven per cent of all the dairy enterprises, while the remaining thirty six per cent and seventeen per cent were jointly and male managed respectively. Unlike female-managed dairy enterprises, male-managed and jointly managed dairy enterprises with *Calliandra calothyrsus* registered significantly higher dairy production (at 5 per cent significance level) than those without.

No significant mean differences in dairy production were observed between those male-managed and female-managed dairy enterprises with and those without the zero grazing dairy technology. It was only within the jointly managed dairy enterprises that significant (0.008) dairy production differences were observed between the adopters and the non-adopters of the technology (zero grazing). However, it suffices to say that very few non-adopters of this technology were found existing in the study area.

The farmers who had adopted the improved fodder plants technology were found to be posting a significantly (P=0.029) higher dairy productivity than the non-adopters of the technology. Significant (p=0.019) mean dairy productivity differences were observed between those male-headed households with *Calliandra calothyrsus* and those without the technology. The female-headed households that had adopted the technology did not show significant difference in dairy productivity from the non-adopter female-headed households.

5.1.3 REGRESSION RESULTS

Several regressions were run to evaluate the effects of socio-economic factors on dairy performance among the smallholder dairy farmers. The Cobb-Douglas production function was estimated for the total sample space then for the male-headed and female-headed households. This was based on the fact that it was the production elasticity for the gender of the household head that was found significant.

The positive production elasticity associated with the gender of the household head for both dairy performance indicators meant that male household heads generally improved dairy performance to a greater extent than female household heads. The results confirmed what was found in the descriptive statistics. Because of African traditional inclinations, male-headed households are mostly endowed with more resources than female-headed households, and this may help explain why the former are better performers in dairy than the latter.

The capital tools and equipment utilized in dairy farming ranged from the simple hoe used in napier grass cultivation, through the milking cans to the bicycle for transporting the milk to the market. A positive relationship between their monetary value and dairy performance underscored the importance of these facilities in dairy farming. Their contribution to dairy performance may partly lie in the fact that the tools and equipment improve operational efficiency, and probably because the farmer realizing higher dairy performance ended up investing more in these facilities than one who was realizing less.

The amount of money earned monthly by the farmer was found to be an important factor

influencing the level of dairy production and productivity. This becomes obvious when it is taken that the monthly income was used to service the operating costs in dairy farming.

It was found that men headed most households (84 per cent). The level of education of the spouse to the household head, rather than the education level of the household head himself or herself was the important factor in dairy performance. The coefficient for this former variable was found to be significant for the general regression and the regression for the male-headed households. It therefore follows that the women's education was positively influencing dairy performance.

The controller of income from milk sales had a positive significant coefficient. This dummy variable was coded as one in cases where the dairy enterprise manager was controlling the income from milk sales, and zero when otherwise. It was found that the controller of income from milk sales influenced the performance of smallholder dairy. The dairy farms where the dairy enterprise manager had a free hand in the control of income from milk sales would realize higher dairy performance than those where he or she was not controlling it freely.

The commercialization index (raw milk market availability) represented one of the strongest signals for increased dairy performance as evidenced by the general level, household level and dairy enterprise level regressions. Milk, being a perishable good, requires a ready market, or has to undergo immediate processing to increase its longevity in circumstances where the market is not readily available. The milk processing market in the area of study had for long been under the monopoly of the Kenya Co-operative Creameries (KCC). The near-collapse of the co-operative without an alternative of similar capacity created a vacuum in the milk market. Though the farmers were not producing a lot of raw milk, the little that

was there could not find market for it. The high production elasticity for the commercialization index implied that a small increase in milk outlet for the farmers would elicit a large response in dairy production and productivity.

5.2. RECOMMENDATIONS

The following recommendations were made based on the findings of the study.

(1) From the descriptive statistics, it was found that improved fodder plants had significant impact on both dairy production and productivity. Similarly, significant differences between adopters and non-adopters were observed when considering gender categories based on who was the head of the household or who was managing the dairy enterprise. Therefore, efforts being made to ensure enhanced adoption of the improved fodder plants technology should be strengthened. There is also a need to institutionalize gender in the efforts being made to improve smallholder dairy performance as opposed to generalizing farming units. A comprehensive study to determine exactly why the adoption levels were low especially among the women farmers should be executed with a view of encouraging higher uptake levels of the technology.

(2) Male-headed households were shown to realize higher dairy productivity than female-headed households. The pattern was explained mainly by the resource endowment differentials existing between those households headed by men and those headed by women. Given the reality of increasing female-headed households, further reductions in dairy performance will be common unless measures to curb the trend are taken. Simulation results indicated that, women headed households would realize higher dairy productivity (as

opposed to dairy production) if given the same resources as those available to the men headed households. Therefore as land sizes decrease, more emphasis on high dairy productivity with fewer animals per farm should be the extension message. This fits well with the women farmers who are better at dealing with fewer dairy animals for increased dairy productivity. Extension staff should never sideline the women farmers in their activities but should deliberately create times and conditions which will enable women farmers to access information.

(3) From the regression analysis, the commercialization index appeared as one of the most consistent factors significantly influencing dairy production and dairy productivity. This was taken to represent milk market availability. Availability of market for raw milk offeres an opportunity as one of the strongest signals for farmers to increase dairy production and productivity. The near collapse of the Kenya Co-operative Creameries should not spell doom to the milk market for the smallholder farmers in Embu district. Ways through which the milk market can be revamped should be investigated. For instance, an investigation to assess the feasibility of setting up private milk processing and marketing co-operatives in Embu District along the lines of those in Kiambu District should be instituted.

(4) Besides the commercialization index, the monthly income was another important factor influencing improved dairy performance in Embu district. This is a case for diversification by the smallholder farmers in the district. Besides dairy farming, there should be a scheme for the smallholder farmers to be provided with credit and training so that one of the spouses may venture into other informal income generating activities that would help raise the family income. The income would help raise dairy performance in addition to creating a

cushioning effect in times of reduced income from dairy occasioned by natural forces and the market forces of demand and supply.

(5) The education level of the spouse to the household head was found to be an important feature in dairy farming. This was found true for the general and male-headed households' regressions. Since men headed most households and women managed most of the dairy enterprises, it follows that this factor captured mostly the education level of the women dairy enterprise managers. Though this may be used to campaign for the education of women in the rural areas, it has been found elsewhere (Saito, 1994) that formal education acts to move farmers away from the rural households to towns. Whether this phenomenon is valid for men farmers or both men and women farmers needs investigation for verification. This notwithstanding, every woman should have access to education which will improve her labor productivity not only in dairy farming but also in other activities aimed at improving the quality of life for many.

(6) It was also found that if the dairy enterprise manager had a free hand in the control of income from milk sales, there would be an increase in dairy performance because the manager would have an incentive to invest more in the management of the enterprise. Since most of the managers of the dairy enterprises were women, there is need for women to be empowered to either own dairy animals or have increased access to and control over the benefits from dairy and any other rural enterprise they are managing. Because of this, they would be able to control the dairy income as managers, instead of the institutional arrangement that confers ownership of dairy animals and control of dairy income either to the man or to them jointly.

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APPENDICES

APPENDIX 1: Mean Dairy farming Input Levels for Male-headed and Female-headed households in Embu district of Kenya.

Type of input	Size in male headed households	Size in female headed households
1.Land		
Total land area (acres)	4.75	5.15
Land area under Napier (m^2)	4210.46	2110.67
2.Labour		
Size of household (No. of persons)	7.5	7.6
Male hired labour (No. of adult persons)	0.4	0.3
Female hired labour (No. of adult persons)	0.0	0.1
3. Capital		
Market value of tools and equipment for dairy (Kshs)		
Gross monthly income (Kshs)	10576.70	8092.90
Quantity of dairy meal bought per month (kg)	12696.70	22177.20
Quantity of bran bought per month (kg)	42.00	26.00
Other commercial meals besides the above (1=yes,	33.30	22.50
0=no)	1	0
Estimated quantity of cut fodder per livestock unit (kg)	48.20	47.20
4. Household characteristics		
Gender of household head (1=male, 0=female)	1	0
Gender of farm manager (1=female, 0=otherwise)	0	0
Years of livestock farming by household head	17.78	21.42
Years of formal education by household head	7.4	3.4
Years of education by spouse to the household head	5.7	5.3

Controller of income from milk sales (1=farm manager, 0=otherwise)	1	1
5. Market and institutional factors		
Milk price (Kshs/700ml bottle)	12.20	12.30
Commercialisation index	4.20	2.33
Distance to milk market (km)	0.96	0.99
Access to credit by household (1=yes, 0=no)	1	1
Frequency of extension visits (1=visited, 0=not visited)	1	0
6. Others		
No. of lactating cows	1.2	1.2
Lactation stage of the cow (months)	9.27	7.98
Number of improved fodder trees on the farm	27.92	2.07

APPENDIX 2: Mean Dairy farming Input Levels for general Male managed, Female managed and Jointly managed households in Embu district of Kenya.

Type of input	Size in male managed farms	Size in female managed farms	Size in jointly managed farms.
1.Land			
Total land area (acres)	5.30	4.90	4.40
Land area under Napier (m^2)	2425.70	5895.90	1909.00
2.Labour			
Family size (No. of persons).	7.60	7.30	7.30
Male hired labour (No. of adult persons)	0.56	0.38	0.32
Female hired labour (No. of adult persons)	0.00	0.00	11.11

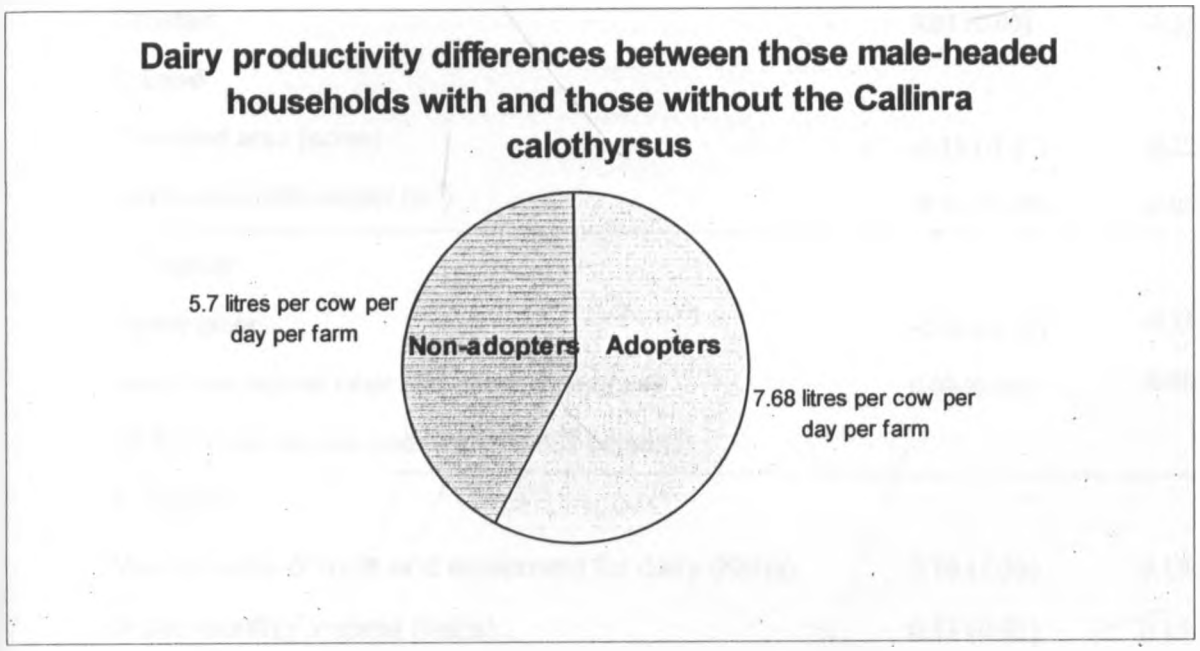
3. Capital			
Market value of tools and equipment for dairy (Kshs)	10576.70	8092.90	8563.00
Gross monthly income (Kshs)	12696.70	22172.20	9845.20
Quantity of dairy meal bought per month (kg)	42.00	26.00	32.00
Quantity of bran bought per month (kg)	35.00	28.00	35.00
Other commercial meals besides the above (1=yes, 0=no)	1	0	0
Estimated quantity of cut fodder per livestock unit (kg)	54.30	47.70	45.50
4. Household characteristics			
Size of household (No. of persons)	8.0	7.0	7.0
Gender of household head (1=male, 0=female)	1.0	1.0	1.0
Gender of farm manager (1=female, 0=otherwise)	0	1	0
Years of livestock farming by household	18.40	17.80	17.40
Years of formal education by household head	7.0	6.0	7.0
Controller of income from milk sales (1=farm manager, 0=otherwise)	0.0	1.0	1.0
Measure of degree of control of resources and output in dairy by household head (1=absolute, 0=otherwise)	1	0	0
5. Market and institutional factors			
Milk price (Kshs/700ml bottle)	12.10	12.40	12.20
Commercialisation index	0.32	0.28	0.35
Distance to milk market (km)	1.20	0.80	1.00
Access to credit by household (1=yes, 0=no)	1.0	1.0	1.0
Frequency of extension visits (1=visited, 0=not visited)	0	0	1
6. Others			
No. of lactating cows	1.0	1.0	1.0
Lactation stage of the cow (months)	9.80	9.30	9.50
Number of improved fodder trees on the farm	34.0	20.0	29.0

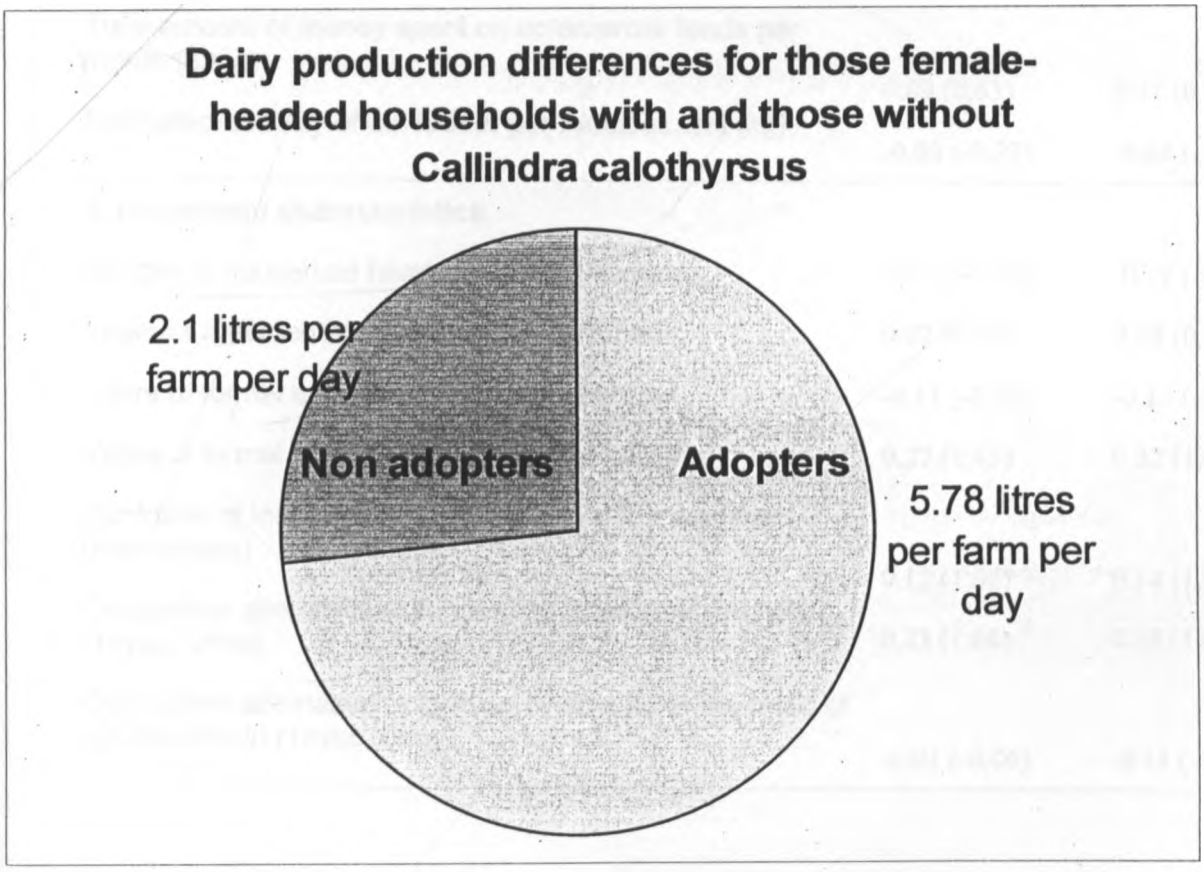
APPENDIX 3 :Mean Dairy farming Input Levels for Male and Female-headed households under various management in Embu district of Kenya.

Type of input	Male headed			Female headed		
	Male managed	Female managed	Jointly managed	Male managed	Female managed	Jointly managed
1.Land						
Total land area (acres)	5.40	4.70	4.50	4.30	5.40	1.80
Land area under Napier (m^2)	2450.5	7527.7	1891.5	2020.6	2088.6	2509.8
2.Labour						
Family labour (No. of adult persons).	2.0	2.0	3.0	3.0	2.0	4.0
Male hired labour (No. of adult persons)	1.0	0.0	0.0	1.0	0.0	0.0
Female hired labour (No. of adult persons)	0.0	0.0	11.0	0.0	0.0	0.0
3. Capital						
Market value of tools and equipment for dairy (Kshs)	10994	8494	8638	3770	7148	5950
Gross monthly income (Kshs)	12905	28577	9839	9293	7075	10067
Quantity of dairy meal bought monthly (kg)	44.30	31.0	30.50	6.70	15.00	70.00
Quantity of bran bought per month (kg)	35.10	30.60	35.10	34.80	20.40	45.0
Other commercial meals besides the above (1=yes, 0=no)	1	1	0	0	0	0
Estimated quantity of cut fodder per livestock unit (kg)	55.10	48.20	45.60	54.30	46.70	60.60

4. Household characteristics						
Size of household (No. of persons)	8.0	7.0	7.0	6.0	5.0	7.0
Gender of household head (1=male, 0=female)	1	1	1	0	0	0
Gender of farm manager (1=female, 0=otherwise)	0	1	0	0	1	0
Years of livestock farming by household head	18.70	17.10	17.40	18.40	19.40	17.70
Years of education by household head	7.0	8.0	7.0	1.0	3.0	4.0
Controller of income from milk sales (1=farm manager, 0=otherwise)	0	1	1	0	1	1
5. Market and institutional factors						
Milk price (Kshs/700ml bottle)	12.15	12.45	12.15	12.15	12.20	12.00
Commercialisation index	0.32	0.29	0.35	0.40	0.25	0.40
Distance to milk market (km)	1.20	0.80	1.50	1.70	0.80	1.20
Access to credit by household (1=yes, 0=no)	1	1	1	1	1	1
Frequency of extension visits (1=visited, 0=not visited)	0	0	0	0	0	0
6. Others						
No. of lactating cows	1.0	1.0	1.0	1.0	1.0	1.0
Lactation stage of the cow (months)	10.50	9.70	9.70	9.90	8.60	3.50
Number of improved fodder trees on farm	36.0	28.0	30.0	0.0	1.0	1.0

APPENDIX 4: Charts showing comparisons of dairy performance between the adopters and non-adopters of improved fodder plants technology





APPENDIX 5: Table showing Regression Coefficients for male-managed dairy enterprises

Explanatory variables	Dairy production	Dairy productivity
Constant	0.01 (0.00)	-1.15 (-0.00)
1. Land		
Total land area (acres)	-0.18 (-1.27)	-0.22 (-1.27)
Land area under Napier (m^2)	-0.51 (-0.40)	-0.06 (-0.41)
2. Labour		
Family labor	-0.21 (-1.50)	-0.25 (-1.50)
Male hired regular labor (No. of adult persons)	0.00 (0.03)	-0.00 (-0.27)
Female hired regular labor (No. of adult persons)	-	-
3. Capital		
Market value of tools and equipment for dairy (Kshs)	0.16 (1.36)	0.19 (1.36)
Gross monthly income (Kshs)	0.13 (0.91)	0.15 (0.91)
Total amount of money spent on commercial feeds per month (Kshs)	0.09 (0.63)	0 11 (0.63)
Estimated quantity of cut fodder per livestock unit (kg)	-0.03 (-0.22)	-0.04 (-0.22)
4. Household characteristics		
Gender of household head (1=male, 0=female)	-0.11 (-1.18)	-0.12 (-064)
Years of livestock farming by household head	0.07 (0.44)	0.08 (0.44)
Years of formal education by household head	-0.11 (-0.58)	-0.13 (-0.58)
Years of formal education by spouse to household head	0.27 (1.45)	0.33 (1.45)
Controller of income from milk sales (1=farm manager, 0=otherwise)	0.12 (1.06)	0.14 (1.06)
Occupation alternative to farming by the household head (1=yes, 0=no)	0.23 (1.66)	0.28 (1.66)
Occupation alternative to farming by spouse to the head of the household (1=yes, 0=no)	-0.01 (-0.06)	-0.11 (-0.06)

5. Market and institutional factors		
Milk price (Kshs/700ml bottle)	-0.01 (-0.08)	-0.01 (-0.08)
Commercialization index	0.19 (1.37)	0.22 (1.37)
Distance to milk market (km)	-0.03 (-0.24)	-0.03 (-0.24)
Access to credit by household (1=yes, 0=no)	-0.00 (-0.03)	-0.01 (-0.03)
Frequency of extension visits (1=visited, 0=not visited)	0.18 (1.35)	0.21 (1.35)
6. Others		
Livestock herd size (livestock units)	0.16 (0.96)	0.20 (0.96)
No. of lactating cows	0.44 (2.10)**	0.03 (0.11)
Lactation stage of the cow (months)	-0.43 (-3.82)***	-0.52*** (-3.82)
Number of improved fodder trees on the farm	-0.57 (-0.42)	-0.07 (-0.42)
Whether zero-grazing unit is present on the farm (1=yes, 0=no)	-0.07 (-0.60	-0.08 (-0.60(
Division (1=Manyatta, 0=Runyenjes)	0.04 (0.33)	0.05 (0.33)
R^2	0.78	0.68
Adjusted R^2	0.57	0.37
Standard error of estimate	0.52	0.52
F statistic	3.71***	2.22**
P value	0.00	0.02

* Significant at 10% level, ** Significant at 5% level

*** Significant at 1% level, t-statistics in parentheses

APPENDIX 6:Table showing Regression Coefficients for female-managed dairy enterprises

Explanatory variables	Dairy production	Dairy productivity
Constant	-0.03 (-0.02)	-0.08 (-0.05)
1. **Land**		
Total land area (acres)	-0.06 (-0.78)	-0.07 (-0.74)
Land area under Napier (m^2)	-0.04 (-0.53)	-0.05 (0.56)
2. Labour		
Family labor	-0.05 (-0.71)	-0.06 (-0.72)
Male hired regular labor (No. of adult persons)	0.04 (0.61)	0.53 (0.62)
Female hired regular labor (No. of adult persons)	-	-
3. Capital		
Market value of tools and equipment for dairy (Kshs)	0.16** (2.02)	0.19** (2.05)
Gross monthly income (Kshs)	0.08 (1.06)	0.09 (1.06)
Total amount of money spent on commercial feeds per month (Kshs)	0.15** (2.12)	0.18** (2.12)
Estimated quantity of cut fodder per livestock unit (kg)	0.02 (0.32)	0.03 (0.33)
4. Household characteristics		
Gender of household manager (1=male, 0=female)	-.02 (0.24)	0.00(0.00)
Years of livestock farming by household head	0.05 (0.73)	0.06 (0.70)
Years of formal education by household head	-0.03 (-0.39)	-0.04 (0.40)
Years of formal education by spouse to household head	0.08 (1.12)	0.09 (1.12)
Controller of income from milk sales (1=farm manager, 0=otherwise)	0.05 (0.80)	0.06 (0.79)
Occupation alternative to farming by the household head (1=yes, 0=no)	-0.01 (-0.12)	-0.01 (-0.14)
Occupation alternative to farming by spouse to the head of the household (1=yes, 0=no)	-0.04 (-0.59)	-0.05 (-0.59)

5. Market and institutional factors		
Milk price (Kshs/700ml bottle)	-0.05 (-0.76)	-0.06 (-0.73)
Commercialization index	0.03 (0.32)	0.033 (0.31)
Distance to milk market (km)	-0.00 (-0.02)	-0.00 (-0.03)
Access to credit by household (1=yes, 0=no)	0.03 (0.41)	0.03 (0.42)
Frequency of extension visits (1=visited, 0=not visited)	0.06 (0.91)	0.07 (0.91)
6. Others		
Livestock herd size (livestock units)	0.08 (0.84)	0.09 (0.83)
No. of lactating cows	0.43*** (4.48)	0.12 (1.04)
Lactation stage of the cow (months)	-0.31*** (-4.47)	-0.37 (-4.46)
Number of improved fodder trees on the farm	0.04 (0.58)	0.05 (0.57)
Whether zero-grazing unit is present on the farm (1=yes, 0=no)	-0.06 (0.98)	-0.07 (-0.97)
Division (1=Manyatta, 0=Runyenjes)	0.12 (1.63)	0.15 (1.63)
R^2	0.60	0.43
Adjusted R^2	0.52	0.31
Standard error of estimate	0.60	0.60
F statistic	7.00***	3.50***
P value	0.00	0.00

* Significant at 10% level, ** Significant at 5% level

*** Significant at 1% level, t-statistics in parentheses

APPENDIX 7: Table showing Regression Results for Dairy Production and Dairy Productivity among jointly managed dairy enterprises.

Explanatory variables	Dairy production	Dairy productivity
Constant	0.50 (0.22)	0.50
1. **Land**		
Total land area (acres)	0.00 (0.05)	0.00 (0.05)
Land area under Napier (m^2)	0.16** (2.42)	0.18** (2.42)
2. Labour		
Family labor	-0.10 (-1.33)	-0.11 (-1.33)
Male hired regular labor (No. of adult persons)	0.00 (0.05)	0.00 (0.05)
Female hired regular labor (No. of adult persons)	-	-
3. Capital		
Market value of tools and equipment for dairy (Kshs)	-0.03 (-0.38)	-0.033 (-0.38)
Gross monthly income (Kshs)	0.40*** (4.65)	0.45*** (4.65)
Total amount of money spent on commercial feeds per month (Kshs)	-0.13* (-1.69)	-0.14 (-1.69)
Estimated quantity of cut fodder per livestock unit (kg)	-0.02 (-0.21)	-0.20 (-0.21)
4. Household characteristics		
Gender of household manager (1=male, 0=female)	-0.08 (-1.38)	-0.10 (-1.42)
Years of livestock farming by household head	0.05 (0.68)	0.06 (0.68)
Years of formal education by household head	0.06 (0.78)	0.07 (0.78)
Years of formal education by spouse to household head	0.02 (0.31)	0.03 (0.31)
Controller of income from milk sales (1=farm manager, 0=otherwise)	0.13** (2.02)	0.14** (2.02)
Occupation alternative to farming by the household head (1=yes, 0=no)	0.14* (1.86)	0.15* (1.86)
Occupation alternative to farming by spouse to the head of the household (1=yes, 0=no)	-0.00 (-0.01)	-0.00 (-0.01)

5. Market and institutional factors		
Milk price (Kshs/700ml bottle)	-0.04 (-0.51)	-0.04 (-0.51)
Commercialization index	0.22*** (2.82)	0.25*** (2.82)
Distance to milk market (km)	-0.10 (-1.51)	-0.11 (-1.51)
Access to credit by household (1=yes, 0=no)	-0.07 (-0.98)	-0.08 (-0.98)
Frequency of extension visits (1=visited, 0=not visited)	0.00 (0.02)	0.00 (0.02)
6. Others		
Livestock herd size (livestock units)	0.13 (1.65)	0.15 (1.65)
No. of lactating cows	0.33*** (3.93)	0.02 (0.18)
Lactation stage of the cow (months)	-0.34 (-4.74)	-0.38 (-4.74)
Number of improved fodder trees on the farm	-0.07 (-0.95)	-0.08 (-0.95)
Whether zero-grazing unit is present on the farm (1=yes, 0=no)	-0.02 (-0.25)	-0.02 (-0.25)
Division (1=Manyatta, 0=Runyenjes)	0.05 (0.60)	-0.06 (-0.60)
R^2	0.71	
Adjusted R^2	0.62	
Standard error of estimate	0.49	
F statistic	8.12***	
P value	0.00	

* Significant at 10% level, ** Significant at 5% level

*** Significant at 1% level, t-statistics in parentheses

APPENDIX 10

	Land size	Livestock herd size	Family labour	Female hired labour	Male hired labour	Market value of tools a	Gross monthly income	Expenditure on comm e	Cut fodder per livestoc	Gender of household h	Years of livestock farm	Years of education for	Years of education for	Controller of income fro	Alternative occupation	Alternative occupation	Milk price	Commercialization leve	Distance to milk selling	Access to credit	Extension	Land size under napier in acres	Months since last calvi	Number of improved fo	Division
Land size	1.0																								
Livestock herd size	.28	1.0																							
Family labour	.04	-.05	1.0																						
Female hired labour	-.03	-.07	-.02	1.0																					
Male hired labour	.26	.47	-.33	.06	1.0																				
Market value of tools and equipment	.24	.37	.00	-.05	.37	1.0																			
Gross monthly income	-.01	.04	-.06	-.01	.11	.10	1.0																		
Expenditure on commercial feeds	.07	.34	-.16	-.02	.44	.22	.01	1.0																	
Cut fodder per livestock unit	.17	.40	-.01	-.03	.23	.40	-.01	.17	1.0																
Gender of household head	.04	-.07	.02	-.02	-.06	-.11	-.04	-.14	-.01	1.0															
Years of livestock farming	.28	.22	.23	-.06	.06	.15	.05	.10	.10	.04	1.0														
Years of education for household head	-.01	.13	-.21	.01	.28	.13	.09	.16	.04	-.40	-.34	1.0													
Years of education for household head	-.10	.06	-.35	.06	.22	.06	.06	.13	-.03	-.01	-.51	.73	1.0												
Controller of income from dairy	.00	.01	-.03	.05	.04	.05	.05	.01	-.05	-.17	-.10	.17	.10	1.0											
Alternative work by household head	-.05	-.07	.17	-.06	-.20	-.02	.03	-.15	-.01	.27	.20	-.56	-.38	-.14	1.0										
Alternative work by head's spouse	-.02	-.27	.18	.02	-.36	-.19	-.01	-.32	-.15	.06	.11	-.39	-.46	.00	.33	1.0									
Milk price	.12	.06	.02	-.01	.06	-.01	-.01	-.02	-.03	-.02	-.04	.01	-.01	.04	-.02	.09	1.0								
Commercialization	.02	.41	-.12	-.02	.33	.30	.02	.62	.20	-.11	.02	.20	.22	.03	-.13	-.33	-.10	1.0							
Distance to market	-.02	.18	-.07	.05	.13	.12	.01	.18	.10	-.01	.00	.00	.00	-.01	.03	-.01	.04	.18	1.0						
Access to credit	-.02	.06	-.03	-.03	-.09	-.03	.06	-.15	.11	.10	-.11	-.10	-.17	-.02	.14	.14	.07	-.04	-.03	1.0					
Extension	-.13	-.06	-.10	-.04	-.07	-.06	.03	-.17	.00	.07	-.10	-.04	.02	-.04	-.01	.07	-.04	-.24	.05	.06	1.0				
Land size under napier in acres	.03	.06	-.06	-.01	.09	.07	.00	.07	-.04	-.03	.04	.02	.01	.05	.04	.01	.00	.12	.01	.10	.03	1.0			
Months since calving	-.10	-.12	-.00	.00	-.06	-.07	.00	-.03	-.05	-.10	.10	-.02	-.03	-.00	.03	-.07	-.03	-.16	.03	-.10	.05	-.03	1.0		
Number of improved fodder plants	.02	-.01	-.03	-.01	.06	.10	.00	.24	.05	-.06	.06	.04	-.01	.03	.06	.02	.18	.07	-.01	.07	-.26	.00	.02	1.0	
Division	-.05	.03	-.03	-.06	.12	.16	.03	-.33	.30	.04	-.16	.02	.04	.01	.06	.03	-.02	-.11	-.06	.14	.10	-.08	-.13	-.13	1.0

APPENDIX 9: Field Questionnaire

Starting time_____ **Ending time**_____

A INTRODUCTION

The interviewer greets the farmer. He/she introduces himself/herself and informs the farmer that he/she is seeking information on milk production in the area. He/she stresses that the information being sought will be used just to complete a masters course in Agriculture (Economics) at the University of Nairobi. The farmer is made to understand that the information he/she will give will be treated confidentially.

B IDENTIFICATION

1. Farm code._____

2. Date of interview._____

3. Name of interviewer._____

4. Village._____

5. Sublocation._____

6. Location._____

7. Division._____

C. DEMOGRAPHICS.

8. Respondent's name_____

9. Are you the registered owner of this farm?

(1) Yes_____

(2) No_____

10. If no, who is the owner?_____

11 .If you're not the owner, what is your relationship with the owner?

(1) Wife_____

(2) Husband_____

(3) Daughter_____

(4) Son_____

(5) Employee_____

(6) Other (specify)_____

12. Marital status of the farm owner

(1) married_____

(2) divorced_____

(3) unmarried_____

(4) widow_____

(5) widower_____

13. Sex of the farm owner

(1) Male_____

(2) Female _____

14. Are you the one operating this farm?

(1) Yes_____

(2) No_____

15. If no, who operates it?_____

16. What is the sex of the operator

(1) Male_____

(2) Female_____

(If the answer to (14) is yes, the following other questions are asked).

17. What is your age, or when were you born?. What of your spouse?

Age_____ _____ (2) Date of birth_____ _____

18. (a) Have you been to a formal school?. (b) What of your spouse?

(1) Yes_____ (1) Yes_____

(2) No_____ (2) No_____

19. (a) If yes, up to what level did you reach?. (b) What of your spouse?

(1) Primary _____ (1) Primary_____

(2) Secondary_____ (2) Secondary_____

(3) University_____ (3) University_____

(4) Other (specify)_____ (4) Other(specify)___

20. Do you have some other occupation(s) other than farming?

(1) Yes_____

(2) No_____

21. If yes, which one(s)

(1)_____

(2)_____

(3)_____

22. How often is the farm owner present at home?

(1) Several days per week_____

(2) Several days per month_____

(3) Several days per year_____

(4) Never at home_____

D. HOUSEHOLD SIZE AND STRUCTURE

23. What is the total number of children you have?_____

24. What is the total number in boarding school?_____

25. What is the total number in paid employment away from the farm?_____

26. How many children stay on the farm?_____

27. Fill in this table below.

	< 2 years	2 - 10	11 - 15	16 - 30	31 - 50	> 50 years
Male						
Female						

Total						

E. FARM DESCRIPTION AND LABOUR

28. Farm size;

Owned _____acre/ha

Rented _____acre/ha

29. How long have you/household kept cattle, or year you first kept cattle? _____

30. How many cattle do you own currently?_____

31. How many of these are grade COWS?_____

32. How many of these are grade calves?_____

33. How many of these are grade heifers (not yet calved down)?_____

34. Do you feed your cattle on any cut fodder?

(1) Yes_____

(2) No_____

35. If yes, which ones?.

(1) Napier grass_____

(2) *Calliandra calothysurs* _____

(3) Maize stovers_____

(4) Lucerne_____

(5) Desmodium_____

(6) Others (specify)_____

36. What land size does each of the fodder occupy?

(1) Napier grass_____

(2) *Calliandra calothysurs*_____

(3) Maize stovers_____

(4) Lucerne_____

(5) Desmodium_____

(6) Others (specify)_____

37. Do you have a zero-grazing unit?

(1) Yes_____

(2) No_____

38. If yes, how many animals does it accommodate?

(1) One to two heads_____

(2) Three to four heads_____

(3) Five to six heads_____

(4) Seven and more heads_____

39. Who taught you how to construct the zero-grazing unit?

(1) Government agricultural extension officer_____

(2) NGO agricultural extension officer_____

(3) Your parents_____

(4) Neighbors_____

40. Have you ever taken a loan in your life-time?

(1) Yes_____

(2) No_____

41. Where did you get the loan from?

(1) A commercial bank/Cooperative society_____

(2) Self-help group_____

(3) Friend or relative_____

42. What did you use the loan for?

(1) Purchase of livestock_____

(2) Purchase of land_____

(3) Building of a house_____

(4) Paying of school fees_____

(5) Others (specify)_____

43. Do you hire labour on the farm?

(1) Yes_____

(2) No _____

44. If yes how many people have you hired permanently?

(1) One_____

(2) Two_____

(3) More than two_____

45. What is the sex of your permanent labour?

(1) Male_____

(2) Female_____

(3) Male and female_____

46. How much do you pay your permanent hired labour per month?_____

47. How many hours per day does your permanent hired labour spend in the following activities?

(1) Milking_____

(2) Taking milk to the market and back_____

(3) Cutting fodder for cattle_____

(4) Watering the cattle_____

48. Do you ever hire casual labour?

(1) Yes_____

(2) No_____

49. If yes, which sex of casual workers do you prefer to employ for the following activities?

(a) Applying manure to crops. (1) Male_____ (2) Female_____

(b) Desuckering and picking coffee. (1) Male_____ (2) Female_____

(c) Weeding purposes. (1) Male_____ (2) Female_____

(d) Harvesting napier/fodder. (1) Male_____ (2) Female_____

(e) Removal of manure from cow shed. (1) Male_____ (2) Female_____

(f) Feeding and watering cattle. (1) Male_____ (2) Female_____

(g) Milking the cows. (1) Male_____ (2) Female_____

(h) Taking milk to the market. (1) Male_____ (2) Female_____

50. How many casuals do you employ per season?_____

51. How many days on average per season do you employ casual labour?_____

52. How much do you pay a casual labourer per day?_____

53. Do you cook lunch for the casuals?

(1) Yes_____

(2) No_____

54. At what time of the day do the casuals report for the day's work?_____

55. At what time do they leave work?_____

56. Fill in the table below for the persons who do the following activities in dairy.

ACTIVITY	**MEMBER (Son/Daughter/ Workman etc.)**	**Gender (Male/Female)**
Cutting feed for Cows		
Watering the animals		
Cleaning around shed		
Weeding for the fodder		
Buying of the inputs		
Spraying the cattle		
Applying manure on fodder		
Milking		
Selling the milk		
Heat detection		

F. MILK PRODUCTION AND DISPOSAL (For Grade/Crosses only)

57. Do you feed your dairy cows on commercial feeds?

(1) Yes_____

(2) No_____

58. If yes, which ones?

(1) Dairy meal_____

(2) Bran_____

(3) Others (specify)

59. How much dairy meal is bought at a time?_____

60. How long do the animals take to finish this amount?_____

61. How much do you spend on the purchase of dairy meal at a time?_____

62. Do you give your cattle salt lick?

(1) Yes_____

(2) No_____

63. In what quantities do you buy the salt?_____

64. How much do you spend on the salt at a time?_____

65. How long does it take for the animals to finish the salt?_____

66. Do you purchase dairy meal and salt lick regularly, i.e. purchase a fresh amount immediately the cattle finish the old stock?

(1) Yes_____

(2) No_____

(3) Depends (specify)

_____

67. How many sacks or wheelbarrows of cut fodder do you feed your cattle per day?_____

68. How many cows do you milk currently?_____

69. How much milk (bottles or litres) is produced by your cows in the morning?_____

70. How much milk (bottles or litres) is produced in the evening?_____

71. How much milk is sold in the morning?_____

72. How much milk is sold in the evening?_____

73. How much milk is consumed by the family in the morning?_____

74. How much milk is consumed by the family in the evening?_____

75. How do the calves feed on the milk?

(1) Suckle direct_____

(2) Bucket-fed_____

76. If bucket-fed how much milk is given to them in the morning and how much is given in the evening?

(1) Morning_____

(2) Evening_____

77. Can you identify how much milk each cow as of now produces?

(1) Yes_____

(2) No_____

78. If yes, fill in the table below.

Cow Number/Name	Bottles or litres in the morning	Bottles or litres in the evening	Days or weeks since calving down
1			
2			
3			

79. Is the milk produced by your cows currently less or more than what was being produced in the last season?

(1) Less_____

(2) More_____

80. How many bottles or litres were being produced last season?

(1) Morning_____

(2) Evening_____

81. How many lactating cows did you have then?_____

82. How often has your favourite cow been calving down? _____

(1) Once every year_____

(2) Once every 2 years_____

(3) Once every 3 years_____

83. What of the other cows?

Cow number or cow name	Calving rate
1	
2	
3	

84. Have all the calves been growing to maturity?

(1) Yes_____

(2) No_____

85. If no, what has been the cause of the deaths?

(1) Diseases_____

(2) Bad weather_____

(3) Any of the two_____

86. Who takes the milk to the market?

(1) Husband_____

(2) Wife_____

(3) Children_____

(4) Workman_____

87. What is the price of milk per bottle or per litre?

(1) Bottle_____

(2) Litre_____

88. How far is the selling point from the homestead?_____

89. What is the mode of transport for the milk from the homestead to the selling point?

(1) Trekking_____

(2) Bicycle_____

(3) Public means_____

(4) Others (specify)_____

90. How long does it take to transport the milk from the homestead to the selling point?_____

91. Who receives or handles income from milk sales?

(1) Husband_____

(2) Wife_____

(3) Other (specify)_____

92. Who receives income from calf sales?

(1) Husband_____

(2) Wife_____

(3) Others (specify)_____

93. Who decides how the money from milk sales or calf sales is spent, i.e. who controls the income from the dairy enterprise?

(1) Husband_____

(2) Wife_____

(3) Others (specify)_____

94. A part from the dairy enterprise do you have the following as alternative sources of income to the farm? Yes or No.

Alternative source of income	Yes or No	Ranking
(1)Paid employment by you or the spouse		
(2)Donations from employed children or relatives		
(3)Coffee		
(4)Tea		
(5)Bananas		
(6)Arrowroots		
(7)Paw paws		
(8)Mangoes		
(9)Others(specify)		

95. Rank the above enterprises in descending order of level of income.

96. What tools and equipment owned and employed in the dairy enterprise are used in the following activities?

ACTIVITY	TOOL OR EQUIPMENT USED AND NUMBER	ESTIMATED COST OR PRICE
Weeding Fodder		
Cutting Fodder		
Collecting Water for dairy purposes		
Watering the Cattle		
Transport of Fodder		
Milking		
Milking Containers		

Transport of milk to Market		

G. MEASURE OF DEGREE OF CONTROL OF RESOURCES

97. Answer YES or NO.

Can you decide:

(i). On when to water the animals?_____

(ii). On when to feed the animals?_____

(iii). On when to clean the cow shed?_____

(iv). On who should milk the cows?_____

(v). On when to spray or dip the animals?_____

(vi). On where to plant fodder crops?_____

(vii). On whether to hire or fire labour on the farm?_____

(viii). On where to sell milk?_____

(ix).To keep money from milk sales?_____

(x). To keep money from milk sales?_____

(a). If NO, who keeps it?

(1) Husband _____

(2) Wife _____

(3) Others (specify)_____

(b). If YES, what level?

(1) All_____

(2) Most_____

(3) Some_____

(xi). On whether to buy cows? _____

(xii). On whether to sell a calf? _____

(xiii). On whether to buy land (assuming money is no constraint)_____

(xiv). On whether to sell land?_____

(xv). On whether to attend an agricultural field day, a workshop or an agricultural tour?_____

98. Would you be better off if you managed the dairy enterprise independently?

(1) Yes_____

(2) No_____

99. If YES, why?._____

_____

100. How often did the agricultural extension officer visit your farm last year?

(1) A number of days per week_____

(2) A number of days per month_____

(3) A number of days in the whole year_____

(4) None at all_____

101. How often did you attend an agricultural seminar, workshop or field day in the last 12 months?.

(1) A number of days per week_____

(2) A number of days per month_____

(3) A number of days in the whole year_____

(4) None at all _____

102. Given an opportunity, would you prefer discussion of dairy matters with male or female extension staff?

(1) Male_____

(2) Female _____

(3) Indifferent_____

Why?_____

103. To which of the following income categories would you estimate your household's monthly income to be? (This is the total gross household income from all sources)

(1) <500 ksh per month_____

(2) 500 - 1000_____

(3) 1001 - 2000_____

(4) 2001 - 4000_____

(5) 4001 - 8000_____

(6) 8001 - 12000_____

(7) 12001 - 18000_____

(8) >18000_____

Thank you very much